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Physical Reactions of Soils to Plow Moldboard Surfaces - - - - - - - - *Nichols and Reed*

Unloading Characteristics of Sprayer Pressure Regulators - - - - - - - - - - - - *K. R. Frost*

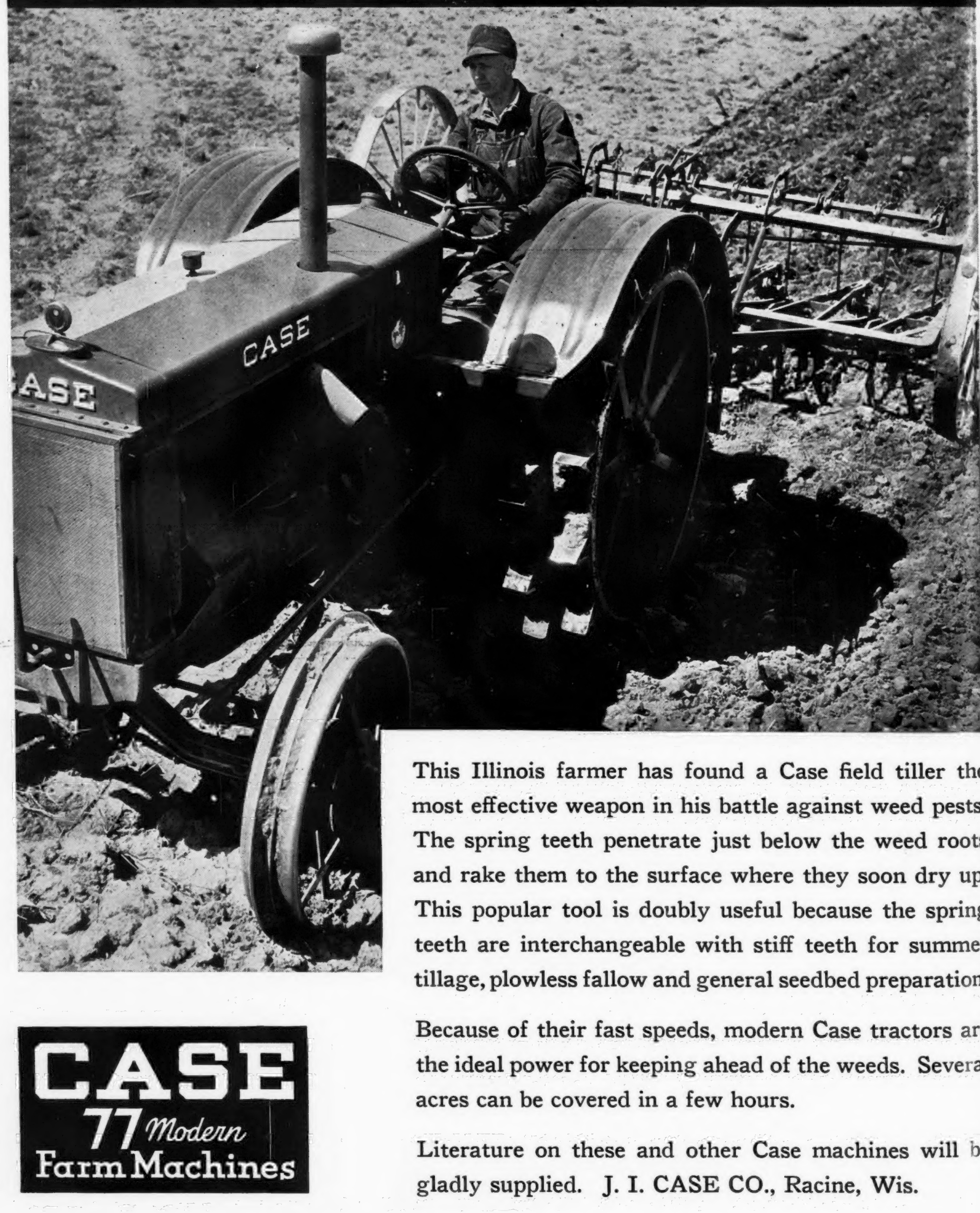
A Study of the Spacing and Depth of Tile Drains - - - - - - - - - - - - - - - *J. H. Neal*

The Relation of Engineering Principles and Physiological Factors in the Field Curing of Hay - - - - - - - - - - - - - *Jones and Palmer*

Water Penetration in the Hardpan of Citrus Orchard Soils - - - - - - - - - - *C. A. Taylor*

VOL 15 NO 6

WINS WEED WAR



This Illinois farmer has found a Case field tiller the most effective weapon in his battle against weed pests. The spring teeth penetrate just below the weed roots and rake them to the surface where they soon dry up. This popular tool is doubly useful because the spring teeth are interchangeable with stiff teeth for summer tillage, plowless fallow and general seedbed preparation.

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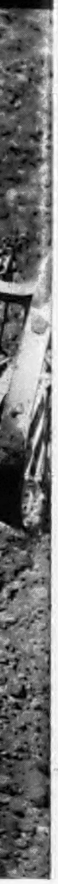

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AGRICULTURAL ENGINEERING

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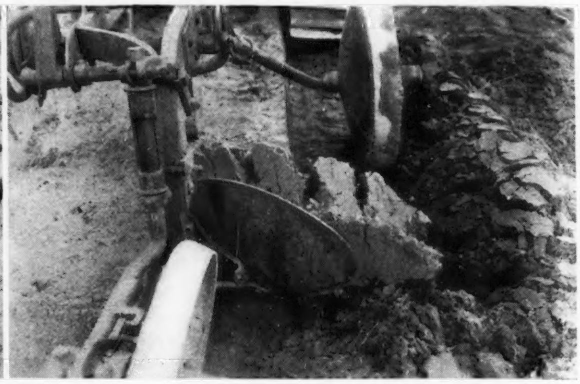


FIG. 2 (LEFT) PHOTOGRAPH FROM IN FRONT OF PLOW SHOWING LOCATION OF PRIMARY SHEAR PLANES IN THE FURROW SLICE AS IT MOVES UP THE MOLDBOARD. CRACKS OPEN ALONG THESE PLANES. NOTE EFFECT OF SECONDARY SHEAR PLANES ON TURNED FURROW. FIG. 3 (RIGHT) PHOTOGRAPH FROM REAR OF PLOW SHOWING CRACKS OPENING ALONG PRIMARY SHEAR PLANES

as will be shown by the description of plow action in this paper.

Push Soils. Soils which when settled react somewhat similarly to loose freshly plowed soils have been termed "push" soils. The adhesion of the soil to the moldboard builds up a pressure ahead of the plow bottom, which, due to lack of sufficient rigidity in the furrow slice to produce slippage on the mold, collapses the furrow wall with the result that the soil is pushed to one side rather than turned.

Normal Condition. The reactions described in this paper are for the normal condition and are those which occur when the soil is settled and has reached the firm condition produced by natural agencies. It should be in that moisture range commonly classified as good plowing condition. Conditions of ordinary stubble and weeds or the inclusion of moderate amounts of rock or gravel, while affecting the reaction, should be included as normal.

Method of Study

Previous studies[4] have shown that the shear angle of soil is normally 45 deg when viewed from the side of the moldboard through a glass surface (Fig. 1), and that the shear planes continued at this angle throughout the plow action. To determine the effect of moldboard shape the reactions over the entire surface must be considered. A group of six plows varying in shape from a slow-turning sod type to a bluff stubble bottom were selected for this purpose. These were typical sod, general-purpose, stubble, black land, and slat bottoms, and one of the gently curving convex type of bottoms common in Great Britain. These were taken for study to a field of moist sand. The soil had been allowed to settle, over a period of several months, to its normal condition and was quite free from weed growth. The sand was selected as slight stresses resulted in visible strains, and the moist condition prevented crumbling of the blocks formed by the shear planes.

Each of the bottoms was mounted in turn on a frame and the necessary adjustments made for smooth running at rated width and various depths. Speeds from approximately ½ to 3½ miles per hour were obtained by the use of a track type tractor. In some cases for better observation of the reactions, all weeds and the loose dry crumbs on the surface of the soil were removed. The reactions were also observed under very moist conditions by wetting the soil with a garden hose. Markers of various kinds were placed in the soil to determine the movements of various portions of the furrow. The plow was stopped frequently and the reactions observed by carefully removing portions of the furrow slice. It was also found that by backing the plow certain types of shear planes showed up very distinctly. In addition to observations and measurements, slow motion pictures were taken and carried to the laboratory for study. Comparison of the reactions between portions of the soil which the tractor had passed over and those which it had not passed over showed no visible differences.

The same kind of reactions were observed for each type of bottom in these soil conditions. Therefore, the conclusion was reached that these were the general reactions sought. To establish the fact that these reactions were not merely characteristic to this soil type and these conditions, the same bottoms were observed and pictorial records obtained in Norfolk sandy loam, Sharkey silt loam, and Sharkey heavy clay. Though the soils for these tests varied from a friable easily plowed sandy loam to a tough plastic buckshot, the general reactions were found to be the same.

General Nature of Reactions

Primary Shear Planes. It was found in these field studies that for all soil conditions the shear planes observed[4] along the shin of the plow (Fig. 1) extended forward entirely across the furrow slice at an angle of 45 deg to the line of travel. This means the angle of shear for soil is a constant, and the horizontal wedge of the plow acts in a manner similar to that of the vertical wedge. The locations of these planes across the furrow slice are shown in the photographs, Figs. 2 and 3, and diagramatically in the unturned furrow slice in Fig. 4. These planes will be referred to hereafter as the primary shear planes.

It will be noted in Fig. 2 that the primary shear planes retained their relative position throughout their passage across the moldboard. When the furrow slice was raised

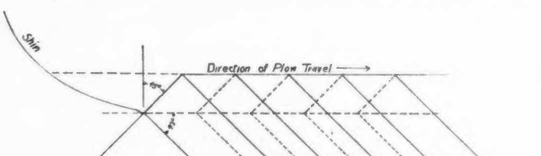


FIG. 4 DIAGRAM SHOWING RELATIVE POSITIONS OF PRIMARY SHEAR PLANES IN UNTURNED FURROW SLICE. THESE PLANES FORM FORWARD FROM THE SHIN AT 45-DEG TO THE HORIZONTAL AND TO THE DIRECTION OF TRAVEL

to the position where it was standing in the furrow on its furrow wall, these planes were practically parallel to the undisturbed furrow wall ahead of the plow. The final action of the moldboard then was to push the upper portion of the slice forward and to the right to make the furrow lie smoothly against the preceding furrow. This is called the "push over" action and is practically the same as that described by Bousfield[5] and illustrated in Fig. 5. Even though a wide range of action is possible, and was observed in the push-over section, the more common action was for the primary shear planes to retain their relative position even after the furrow slice had passed the plow and was resting against the preceding furrow. In the heavier soils this was still more apparent than in the lighter soils. It should be noted that these primary shear planes move but little from the plane in which they were originally formed. Under ideal conditions the furrow is inverted progressively by the rotation of these blocks forward and to the right at an angle of approximately 45 deg to the line of travel until the block stands on end. It is then pushed over still forward and to the right, pivoting on the upper edge of the furrow wall as shown by Bousfield. However, the diagram of Bousfield does not show the forward part of the motion as it represents only a cross section of the slice at right angles to the line of travel. The findings of Ashby[6], a typical example of which is shown in Fig. 6, quite conclusively shows the forward action which occurs in turning.

Tension Effect. It will be noted in Figs. 2 and 4 that the primary shear planes have a tendency to open as the soil inversion progresses. These illustrations were selected as they show conditions where this action was rather extreme. This kind of reaction was observed on all soils studied.

If the soil blocks are not completely sheared apart and adhere, obviously the forces producing the opening, shown above, would produce an effect of tension. This opening force is due to variations in directional accelerations occurring on different parts of the moldboard, therefore the action over the entire moldboard surface must be considered in explanation. It should be noted that the speed of soil travel is practically constant over the moldboard surface as has been previously shown[7]. The force causing the soil to slide over the moldboard is applied practically uniformly across the entire furrow slice. The left or shin side is lifted before the right side of the furrow slice. Due to the 45-deg angle of the share, the bottom of the right side is not smoothly sheared until the block is nearly turned on edge. The left side of the block is stressed to conform to the shape of the moldboard before the right side (a very important consideration as will be shown later), and consequently it is in a looser condition and less able to transmit the force of resistance causing the soil to slide up over the moldboard. The action may be described more simply if the plow is thought of as standing still and the soil moving over its surface. The soil on the left side of the furrow is moving upward while that on the right is approaching the plow in the line of travel. Consequently, as the weight of the soil block is transferred to the right side of the furrow, the motion of the block is more and more affected by the direction of the right-hand side of the slice and shear planes open at the top or left-hand side of the turning furrow. The effect will also be more understandable when it is remembered that the greatest curvature in the path of travel of a particle is near the shin; therefore the motion changes rapidly from one up the moldboard to a motion towards the right. This is equivalent to stating that the tension cracks are formed near the part of the moldboard where the "warping" occurs.

It has been shown[8] that the moldboard surface may be described by parametric equations, which define the angular rotation of arcs of circles around a point moving on, or near, the line of travel of the tip of the share wing. When these angles were plotted on semi-logarithmic paper as functions of time or travel, they gave a series of straight lines. The first breaks in the slopes of these lines occurred at the place where the cracks opened, thus explaining the change in directional acceleration, which caused the cracks to open. It should be noted also that other breaks in these lines occurred at the same times that "push over" becomes effective.

Secondary Shear Planes. It has been shown that the primary shear planes are formed at 45-deg angles forward from the plane of the shin. The plow share runs backward from the point at an angle of approximately 45 deg, and

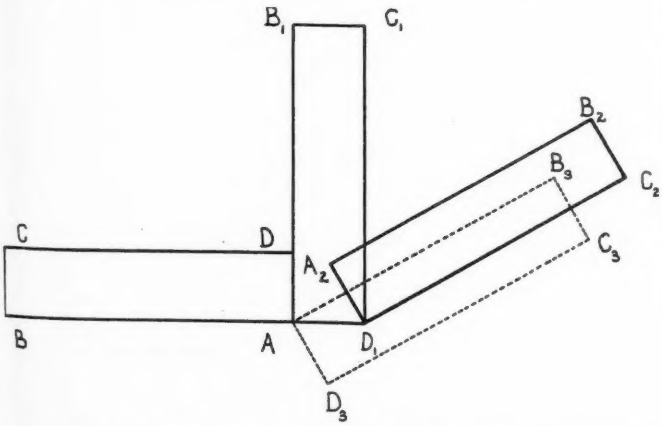


FIG. 5 BOUSFIELD EXPLAINED PLOW ACTION GEOMETRICALLY BY STATING THAT THE FURROW SLICE ABCD IS FIRST ROTATED ABOUT CORNER A UNTIL IT REACHES POSITION AB'C'D' THEN ABOUT D'. THE EXPLANATION IS INCOMPLETE AS IT DOES NOT CONSIDER SOIL REACTIONS

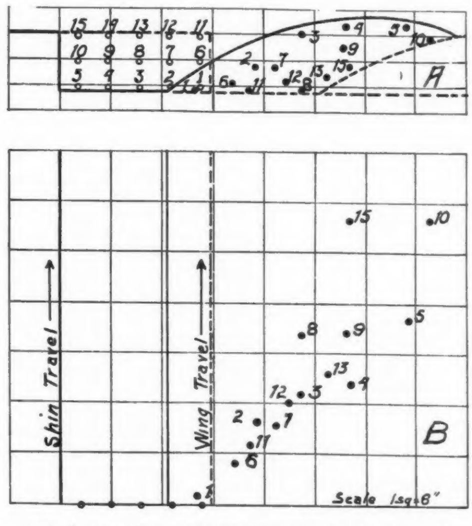


FIG. 6 TYPICAL LOCATION DIAGRAM OBTAINED BY ASHBY AND HIS ASSOCIATES IN THE U.S.D.A. BUREAU OF AGRICULTURAL ENGINEERING IN THEIR STUDY OF THE ACTION OF VARIOUS PLOW BOTTOMS BY PLACING BLOCK IN VARIOUS POSITIONS OF THE FURROW SLICE (OPEN CIRCLES) AND NOTING THEIR SUBSEQUENT POSITIONS IN THE TURNED SOIL. PERMISSION FOR ITS PUBLICATION WAS OBTAINED BECAUSE OF ITS PERFECT ACCORD WITH THE FINDINGS SET FORTH IN THIS PAPER

therefore the soil blocks formed by the primary planes are being lifted progressively from the shin side by a surface approaching at right angles to the primary planes. Disregarding the variations necessary for suction and mechanical strength at the point and along the share it has been shown[8] that a perpendicular plane, at right angles to the plane of the shin, cuts off a forward portion which may be divided into two symmetrical parts by a plane bisecting the angle formed by these two planes. This portion was called the pulverization area of the plow and may be swept out by lines parallel with the share. This means that the pressure of the advancing surface, as shown by the direction of the normals, would tend to progressively produce other shear planes appearing at the surface at an angle of 90 deg with the primary shear planes. This was found to occur, and the shear planes so produced were termed secondary shear planes.

The secondary planes do not open until the furrow falls in inversion and may escape detection by the casual observer. They are, however, readily shown to exist by backing the plow as has been done in Fig. 7. They are also very apparent in the turned furrow shown in Figs. 2 and 3.

While it is not within the scope of this paper to discuss fully the relationship between plow action and soil characteristics, a few important examples will be pointed out as indicating their importance to the selection and the design of plows.

Bacon[9] states that bluff moldboards are necessary for sandy soils. The necessity for this is shown by the shear reaction. The low shear value of sand necessitates the lifting of the furrow slice while it is being strongly supported by the soil in front of the plow or otherwise the furrow wall collapses and poor coverage results. Stiff soils require very gently sloping moldboards because of their high resistance to shear. Otherwise the furrow slice refuses to bend to form the secondary planes and travels upward on the moldboard, but does not turn, with the result that large blocks are thrown to the left, sometimes falling at right angles to the line of travel. The same reaction occurs when the speed of the plow is increased, since the force required for soil to slide over soil is not independent of speed. The reaction is the same as that described under A-phase friction[10]. When the stiffness of soil is reduced by sufficient moisture, most any plow shape will turn the soil but puddling may occur.

In sod the binding power of the roots retards the formation of both primary and secondary shear planes and prevents the furrow wall from crumbling; consequently, a long gentle sloping moldboard is required.

The work of Ashby[11] and his associates in studying coverage indicates that better coverage was produced by plows with moldboards which were relatively steep at the mid-section. This shape of moldboard produces very decided secondary shear planes. It must be recognized, of course, as shown by the same author, that satisfactory coverage may be largely effected by supplementary equipment.

For soil conditions which do not require great pulverization or for soils too stiff to permit it, it would appear that the English type of plow would be of great advantage as the convex surface should result in reducing the force required to produce secondary planes. This opinion, however, requires verification by careful controlled field tests.

SUMMARY

The physical reactions of soil in various conditions to plow surfaces are classified. The reaction of soil in "normal" or good plowing condition is described from field studies.

FIG. 7 BOTH PRIMARY AND SECONDARY SHEAR PLANES SHOW UP CLEARLY WHEN A PLOW IS BACKED UP. THE FURROW WHEEL WAS REMOVED AFTER THE PLOW WAS IN POSITION

The pulverization of the slice was found to be produced by two sets of shear planes. The primary planes were formed by the wedge action of the point of the plow and extended upward and forward from the shin at an angle of 45 deg to the direction of travel. The secondary planes were formed at right angles to the primary planes, thus the soil was sheared in two directions to produce pulverization. The slice was turned by the rotation of the blocks formed by the primary planes upward and forward. The blocks were lifted so that they stood on the portion which was the furrow wall and were then pushed over forward to lie against the preceding furrow. The so-called "tension" effect of the plow was found to be due to variations in directional acceleration.

The relationship of these reactions to plow design is briefly indicated.

Technical Language

WHAT does the non-technical man think about when he overhears the shop talk of engineers? There is little doubt that he accepts as unavoidable and therefore proper those terms that are utterly foreign to his vocabulary, like "modulus of elasticity" or "hydrogen-ion concentration." But those composed of familiar words that throw off their accustomed meaning are likely to be disturbing. What mental image, for example, is conjured up for him by the term "bending moment"? Certainly not that of a structural member subjected to flexure. He may envision some Einsteinian mad-land in which time and space are hopelessly tangled. "Moment of inertia" probably recalls to him the climactic knockout finish of the last major prize fight, while "influence line" reminds him of the time he asked his political friend to have his traffic violation ticket "fixed." And surely his attempt to read some meaning into the puzzling "loss of head" of the hydraulic engineer is apt to involve mental pictures of Ichabod Crane on a dark night, or of Louis XVI or an unpleasant day in Paris; especially as "loss of head" is measured in feet. Technical language at its best is not a favorable medium for the information of the layman; the more reason why engineers today, when engineering works are so much in the public mind, should cultivate clearness if they wish to gain and hold the essential public support.—*Engineering News-Record*, Jan. 18, 1934.

The Unloading Characteristics of Orchard Sprayer Pressure Regulators

By K. R. Frost[1]

ORCHARD SPRAYERS are equipped with a regulating device that serves a twofold purpose of (1) a pressure-relief valve and (2) an unloading device for the power unit while the spray lines are not operating. Some regulators do not fulfill the second function, for the load on the engine is not affected when the spray lines are closed. As a relief valve, however, the average pressure regulator operates quite efficiently and seldom fails to serve as a safety device on the pump.

In recent years many troubles have been experienced with pressure regulators, especially since operating pressures have increased to 600 and 700 lb per square inch. During a short period of operation, the valve balls, seats, and stems are eroded in some cases, until the regulator no longer functions properly. High velocities of the liquid through the valves and the presence of abrasives are the direct causes for this excessive wear. The velocity may also cause back pressure on the pump and thus prevent unloading of the power unit when the spray lines are closed.

In Fig. 1 appears a cross section of the principal parts of a regulator. The pressure is controlled by the pump pressure against a diaphragm or piston. The latter, in turn, is counteracted by a compression spring until a certain pressure is reached, depending upon the spring tension. This may be adjusted by the setting of the pressure control nut, affecting the valve stem position as indicated in Fig. 1 by S_1 and S_2. The setting of this nut changes the clearance of the valve stem and the valve ball when the pump is not operating. The valve ball remains seated until the pressure on the diaphragm is sufficient to compress the spring and close the valve stem clearance, besides lifting the ball against the pump pressure. The pressure on the diaphragm is held by the check valve until the spray line is again opened.

[1]Associate in agricultural engineering, University of California. Jun. A.S.A.E.

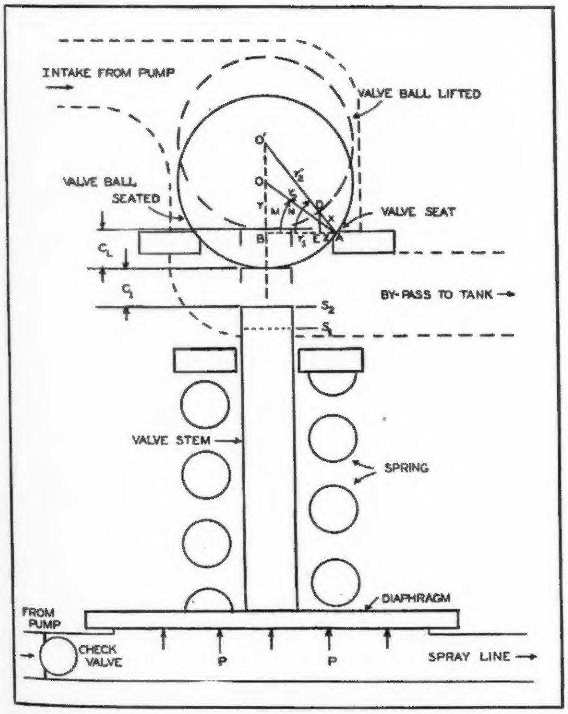


FIG. 1 PRESSURE REGULATOR DIAPHRAGM, SPRING, AND VALVE

The pressure P_1 required to close the clearance C_1 may be determined by the equation $P_1 = (C_1 \times S_c) \div A$, if S_c is the spring constant in pounds per inch and A is the area of the diaphragm. The pressure P_L required to lift the ball from the seat is determined from the force balance equation, $P_L A = a\,(P_1 + P_L)$, where a is the area of the valve seat (neglecting the spring forces, as the ball must be lifted only an infinitesimal distance to relieve the pressure). Solving the equation, the result is $P_L = aP_1 \div (A - a)$. Evidently, then, the distance the valve is lifted, as $C_L = (P_L \times A) \div S$, depends on several factors, namely, the valve-seat area, the difference between diaphragm area and valve-seat area, the valve clearance and the spring constant. Since the valve lift is a measure of the reduction in pressure, the unloading characteristics depend largely upon the design of the regulator.

The area between the valve ball and seat, if known, enables one to determine the back pressure on the pump caused by the regulator and to check up on the by-pass pressure and the power consumed by the pump. The following notations and derivations applying to Fig. 1 indicate a solution for calculating the area between the valve ball and seat:

Angle M, = OAB describes the position of the ball when seated.
Angle N, = O'AB describes the position of the ball when lifted.
r_1 = BA, radius of the valve seat.
r_2 = OA, radius of the valve ball.
z = EA; y = OB.
$x = AD = r'_2 - r_2$, minimum lineal clearance.
Q = quantity of liquid flowing, second-feet.
C_c = coefficient of contraction.
C_v = coefficient of velocity.
C = coefficient of discharge $= C_c \times C_v$.
A_c = area at minimum clearance, square feet.
V = velocity of approach, feet per second.
P_b = back pressure, pounds per square foot.
w = weight of a cubic foot of liquid, pounds.
g = gravity = 32.2 feet per second per second.

Solving for x and z,

$$y = \sqrt{r_2^2 - r_1^2} \text{ from the right triangle ABO}$$

$$r'_2 = \sqrt{r_1^2 + (y + C_L)^2}$$

The area A_c at the minimum clearance is the surface of a frustrum of a cone with r_1 and $r_1 - z$ as the radii of the bases.

The surface area of the frustrum of a cone equals one-

half the product of the sum of the circumferences of the bases and the slant height, or

$$A_c = \frac{x}{2}\left[2\pi\,(r_1 - x\cos N) + 2\pi\, r_1\right]$$

and

$$A_c = \pi x\,(2r_1 - z).$$

The velocity V_c at x may be found from the amount of liquid passing that point divided by the area A_c and the coefficient of contraction C_c, or

$$V_c = \frac{\text{gpm}}{C_c\, A_c \times 449}$$

The velocity at the minimum clearance causes the back pressure on the pump, P_b, which can be calculated by the hydraulic equation

$$Q = C A_c \sqrt{2g\frac{P_b}{w} - V^2}$$

The velocity of approach, V, is negligible in comparison with $2g\,P_b \div w$, as seen by inspection; therefore, it may be eliminated without an appreciable error.

Substituting and solving for P_b,

$$V_c = C_v \sqrt{\frac{2g\,P_b}{w}}$$

and

$$P_b = \frac{V_c^2 \times w}{2g\, C_v^2}$$

By applying these values for any regulator at various valve lifts, one may calculate the back pressure and the power required to operate the pump while by-passing. The calculated back pressures for three regulators are given in Table I, using the dimensions in Table II, and are plotted graphically in Fig. 4.

Experimental Tests

The pressure regulators were tested on two three-cylinder spray pumps having capacities of 16 and 20 gpm (gallons per minute) and capable of developing pressures of 600 lb per square inch without endangering the equipment. They were driven by chain-and-sprocket-equipped electric motors.

The pressure was varied from 200 to 600 lb per square inch during the tests, the range ordinarily used for spraying

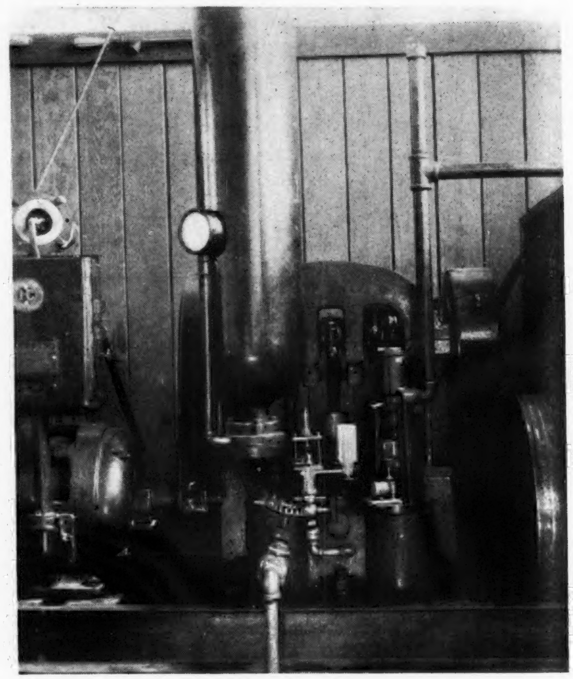


FIG. 2 A STATIONARY ORCHARD SPRAYER EQUIPPED WITH A DIAPHRAGM TYPE PRESSURE REGULATOR. THE STEAM-ENGINE INDICATOR USED FOR MEASURING PISTON PRESSURES AND THE MICROMETER GAGE FOR MEASURING VALVE LIFT ARE SHOWN IN FOREGROUND

purposes. The change was made by loosening or tightening the spring tension nut on the regulator. Because the valve-stem clearance was then affected, as noted in Fig. 1, it had to be measured each time between test runs.

The stem clearance and valve lift were measured with a micrometer gage attached to the base of the regulator, the micrometer gage pin being placed under an arm on the valve stem so that any change in position was registered. When only atmospheric pressure was exerted against the diaphragm or piston, the gage was set for zero. Then stem clearance was registered by the gage as the valve stem was raised to a point contacting the valve ball. The spray lines

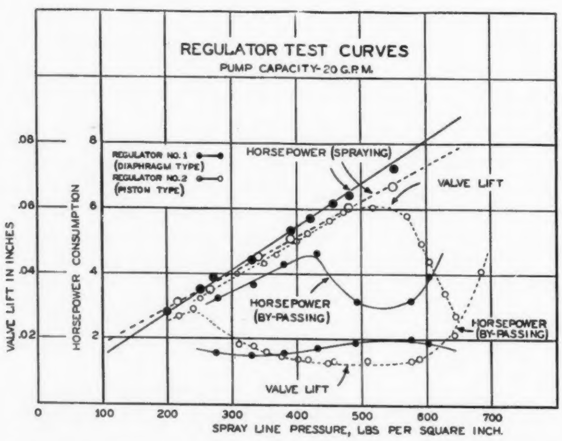


FIG. 3 PERFORMANCE CURVES ILLUSTRATING THE OPERATING CHARACTERISTICS OF PISTON AND DIAPHRAGM PRESSURE REGULATOR

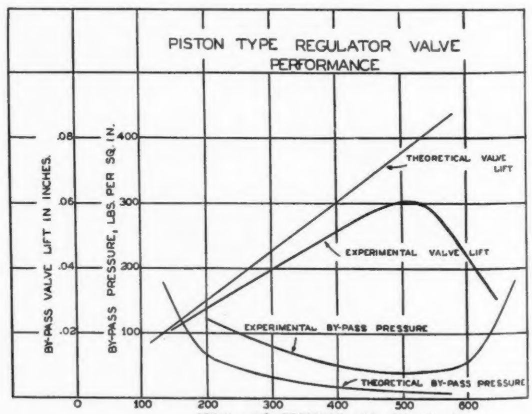


FIG. 4 EXPERIMENTAL AND CALCULATED VALVE LIFTS AND BY-PASS PRESSURES OF A PRESSURE REGULATOR. THE WIDE VARIATIONS ARE DUE TO CHECK VALVE LEAKAGES AND FLOW RESTRICTIONS OTHER THAN THE BY-PASS VALVE

TABLE II. THE DIMENSIONS AND SPRING CONSTANTS FOR PRESSURE REGULATORS TESTED IN THIS EXPERIMENT

Regular number	Dia. of diaphragm or piston, in	Area of diaphragm or piston, sq in	Seat dia. of by-pass valve, in	Seat area of by-pass valve, sq in	Dia. of by-pass valve ball, in	Spring constant lb per in	Spring length, in
1	3.25	8.30	0.875	0.603	1.38	6666	2.90
2	2.50	4.92	1.00	0.786	1.25	6160	4.25
3	2.75	4.95	0.75	0.442	1.38	8850	1.95
4	2.00	3.14				960	5.50

TABLE I. PISTON PRESSURES FOR VARIOUS VALVE LIFTS AS CALCULATED FOR THE PRESSURE REGULATORS USED IN THE TESTS

C (coefficient of discharge) = 0.94*

Regulator	Discharge gpm	Valve lift (C_L), in	Area at valve (A_c), sq in	Velocity at valve (V_c), ft per sec	Calculated pressure (P_b) lb per sq in
1		0.01	0.0245	262.0	485.0
		0.015	0.0352	182.5	258.0
		0.02	0.0435	147.5	166.5
	20	0.03	0.0648	99.1	75.0
		0.04	0.0885	72.5	40.1
		0.05	0.1097	59.7	26.4
		0.06	0.1300	47.6	17.3
2		0.01	0.0187	274.0	572.0
		0.015	0.0275	187.0	267.0
		0.02	0.0372	138.0	144.0
	16	0.03	0.0587	87.2	58.0
		0.04	0.0770	66.7	33.8
		0.05	0.0960	53.5	21.8
		0.06	0.1150	44.7	14.1
3		0.01	0.0165	282.0	608.0
		0.015	0.0260	214.7	353.0
		0.02	0.0372	138.2	144.4
	16	0.03	0.0552	84.5	54.6
		0.04	0.0758	67.0	34.1
		0.05	0.0938	54.6	22.6
		0.06	0.1140	45.0	15.8

*An average figure for small conical-area orifices.

were then closed, causing the pressure to rise, lifting the ball, and allowing all the water to by-pass. This rise of the valve stem was indicated on the micrometer gage. The valve lift was the difference between the readings.

The average piston pressure while the pump was by-passing was determined with a steam-engine indicator that gave the area under a penciled curve. The average height of the curve represented the pressure for one revolution of the pump. The electric horsepower was measured for each valve setting under both conditions, spraying and by-passing. To determine the horsepower input to the pump, the load-efficiency curve of each motor was used, thus providing an accurate check on the actual power requirements while the pump was by-passing and a comparison with the power required for operating the spray line. The pump discharge, as measured with a set of scales for periods of several minutes, varied, throughout the tests, only 0.1 to 0.5 gal from the rated capacity.

Three standard type regulators and one relief valve type were tested. The latter and one of the former were piston types; the others were diaphragm types. The results are plotted in Fig. 3 for comparison. No. 1 was a diaphragm regulator on a pump discharging 20 gpm, and No. 2 was a piston regulator on a pump discharging 16 gpm. The curves plotted from the horsepower data and from the valve lift show a definite relation, as indicated by Table I; that is, the greater the valve lift, the less are the back pressure on the pump and the horsepower consumption. The curves follow the pressure-horsepower curve of the pump to the point where the pressure is sufficient to lift the piston or diaphragm and open the by-pass valve. The horsepower consumption then remains approximately constant until high pressures cause leakage at the check valve and the regulator no longer functions as an unloading device. The curve again turns upward, approaching the pressure-horsepower curve of the pump.

On regulator No. 3 the valve stem clearance was varied in order to determine the effect on horsepower consumption. The results are plotted in Fig. 5. A clearance of 0.024 in proved to be the most effective setting to obtain minimum by-pass horsepower for this regulator. The lowest point on the curve occurred at 370 lb per square inch and was one-third of the power required to operate the spray lines at that pressure.

The fourth regulator tested was a recent development designed to replace the standard-type regulators. It consisted merely of a piston, a cylinder, compression spring, and by-pass ports, and served as a safety valve and a pressure-control device but not as a power-unloading unit. It was tested on a 20-gpm pump between pressures of 200 and 600 lb per square inch. The results are plotted in Fig. 6, and the curves indicate an increase in power for by-passing compared with the operating-power consumption. In this case the pressure increases when *(Continued on page 197)*

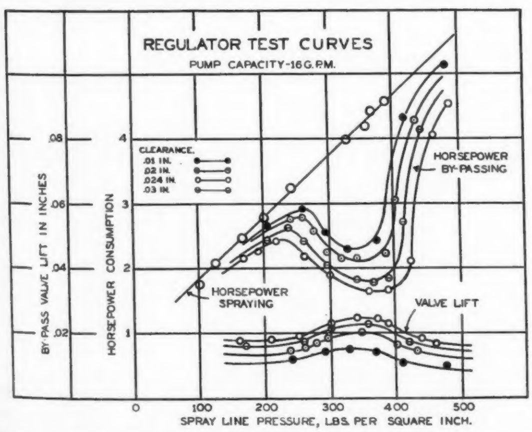


FIG. 5 CURVES SHOWING THE EFFECT OF CHANGING THE VALVE STEM CLEARANCE ON THE POWER CONSUMPTION

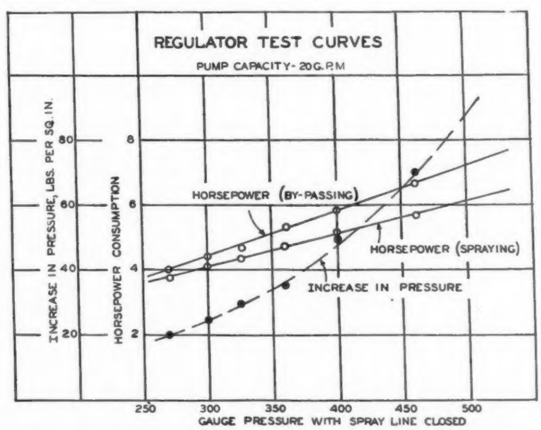


FIG. 6 THE OPERATING CHARACTERISTICS OF A RELIEF-VALVE TYPE OF PRESSURE REGULATOR

Spacing and Depth of Tile Drains[1]

By J. H. Neal[2]

THE PROPER SPACING and depth of tile lines has long been a perplexing problem. In most cases for many years the tile drainage systems were installed with a certain spacing and depth because another successful system had been put in with such a spacing and depth. The irrigation engineers have already worked out relationships between soils and amounts of irrigation water to apply, but the drainage engineers, with the exception of the German, have failed to find a satisfactory relationship between the soil and rate of water movement through the soil. Most of the American investigators give only general recommendations which are not readily interpreted by others, while most of the German investigators give some type of formula.

The author has made a study of four tile drainage systems in different parts of Minnesota where there is a wide variation in soil type. Although the tile drainage systems were not installed for experimental purposes, nevertheless there was a variation in spacing at each of the stations studied and a variation in depth as between the stations.

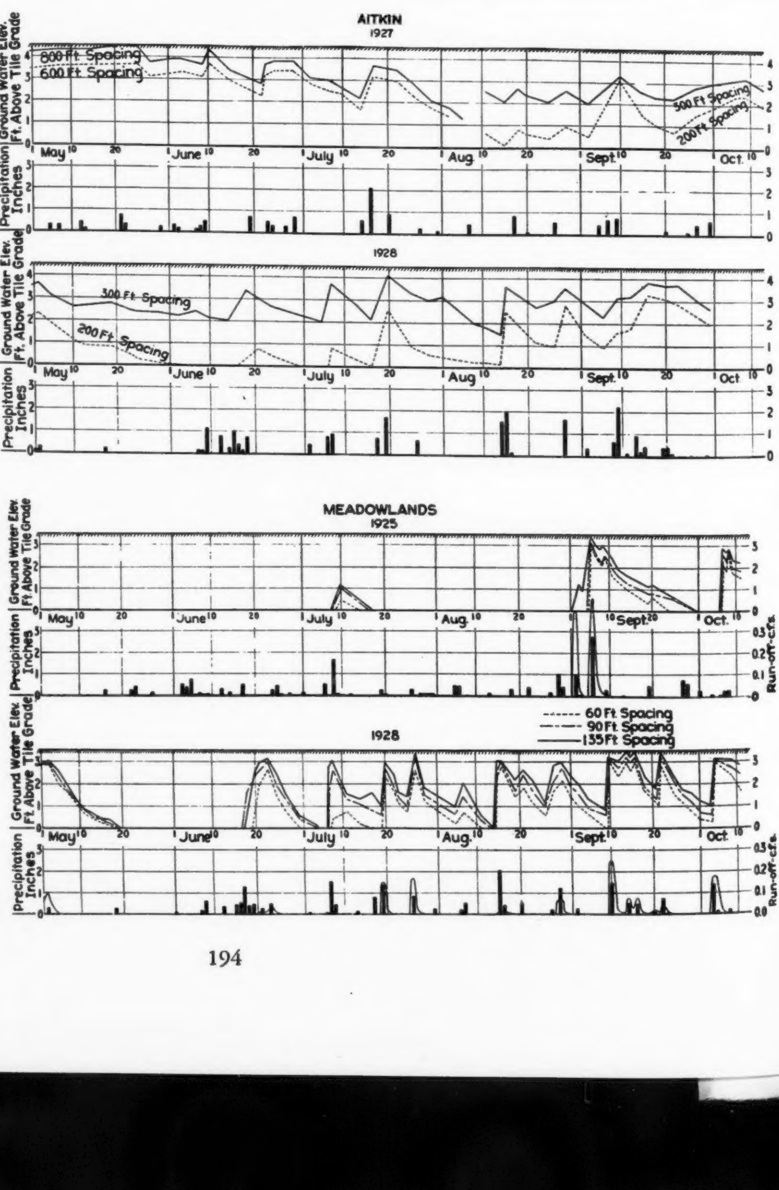
Study of the fluctuation of the ground water table due to precipitation was made at each of these stations over a period of four years, 1925 to 1928. These studies were largely based on contemporaneous records of the duration and amount of local precipitation secured at or near the drainage areas.

Precipitation. In the latitude of Minnesota the winter precipitation has very little effect upon the local ground water table, since the snow melts and runs off before the ground thaws in the spring. Practically all precipitation falling between November 1 and March 1 is snow and can be disregarded as far as the design of a tile drainage system is concerned. The precipitation for the four winter months is low, averaging less than one inch per month. The precipitation for March and April may be either snow or rain. Frequently the precipitation for March also runs off while the ground is still frozen.

In all cases there were one or more months during the growing season of each year in which the precipitation was below normal. With the exception of 1927 there were also one or more months each year in which the precipitation was above normal. In general the periods of excess precipitation were shorter than those of deficient precipitation.

About half the precipitation comes in rains of less than one inch, one-fourth in rains of 1.00 to 1.99 in, and one-fourth in rains of 2.00 in or more. The larger rains occur for the most part during the summer months.

In general the big rains, those of 2.00 in or more, occur when there has been less than one inch during the previous seven days. During the four-year period of this investigation, there was a total of 28 rains of 2.00 in or more at the four stations, twenty-four of these coming when there had been less than one inch of rain during the previous seven days. About half of the big rains occurred when there had



FIGS. 1 AND 2 GROUND WATER PROFILES AT MID-POINT BETWEEN TILE LINES AND DAILY PRECIPITATION, AT THE AITKIN AND MEADOWLANDS STATIONS

[1]Paper presented at the 28th annual meeting of the American Society of Agricultural Engineers, at Detroit, Michigan, June 18 to 20, 1934. Approved as Journal Series Paper No. 1274 of the Minnesota Agricultural Experiment Station. Abstract of professional engineering thesis approved for publication as Minnesota Technical Bulletin No. 101.

[2]Assistant professor of agricultural engineering (land reclamation), University of Minnesota. Assoc. Mem. A.S.A.E.

[3]Rothe, Joh.—Die Strangentfernung bei Dranungen in Mineralboden. Der Kulturtechniker 32: 155-169 (April 1929), Konigsberg, Germany.

TABLE I RUN-OFF FROM DRAINAGE AREAS AT MEADOWLANDS AND PAINESVILLE

(Expressed in inches of depth)
April 1 to October 15, inclusive

Item	Meadowlands 1925	1926	1927	1928	Total	Paynesville 1925*	1926	1927	1928	Total
Total run-off, in	0.52	0.55	0.00	3.59	4.66	0.00	3.16	1.07	0.11	4.34
Total precipitation, in	20.00	16.72	14.71	26.00	77.43	3.81	25.52	18.62	19.08	67.03
Per cent as run-off	2.60	3.30	0.00	13.80	6.00	0.00	12.40	5.70	0.60	6.60
Rains causing run-off, in	3.85	2.54	0.00	20.50	26.89	0.00	18.15	9.73	3.44	31.32
Per cent as run-off	13.50	21.60	0.00	17.50	17.30	0.00	17.40	11.00	3.20	13.90
Precipitation { above / below normal**, in	+1.05	—2.23	—4.24	+7.05	+1.63	—3.92	+3.58	—3.32	—2.86	—6.52

*August 1 to October 15, inclusive.
**Normal for Paynesville taken from records for St. Cloud.

been less than 3 in in the previous 30 days and half when there had been 3 in or more in the previous 30 days. This was true not only for the four-year period of this investigation but also for the ten-year period preceding.

Although the four-year period of this investigation was one of deficient rainfall, the precipitation being above normal in only one year out of the four for each of the stations at Aitkin, Meadowlands, and Paynesville, and below normal for all four years at Waseca, nevertheless more large rains occurred than in the preceding ten-year period.

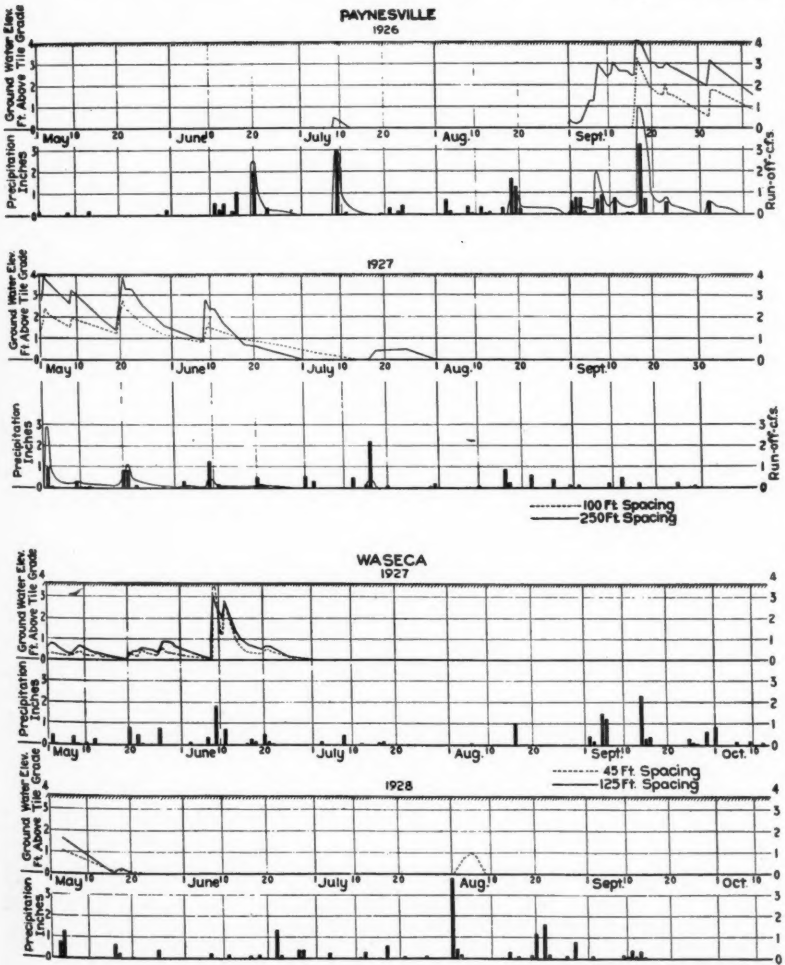
Run-Off. Since the amount of run-off is dependent upon so many variable factors, the per cent of run-off varies widely. Some of the most important factors are (1) amount and intensity of rain, (2) previous precipitation, (3) transpiration, (4) evaporation, and (5) deep seepage. The first three are by far the most important, although deep seepage is a noticeable factor at Meadowlands, there being an abrupt drop of 20 ft to the river at the east edge of the field.

The total precipitation and total run-off for the Meadowlands and the Paynesville stations are given in Table I. When the precipitation is below normal, the run-off also is low or even becomes zero. This was the case at Meadowlands for the first eight months of both 1925 and 1926, and for all of 1927. At Paynesville, 1925, the last half of 1927, and 1928 were so dry that no appreciable run-off occurred.

In general when there has been less than 3 in of rain during the previous 30 days, a rain will cause little if any run-off. Rains of less than 1 in occurring during the growing season are not likely to cause run-off unless they are preceded by 4 in or more of rain in the previous 30 days. Practically all rains of more than 1 in, when preceded by 3 in or more in the previous 30 days, will cause run-off, and also a decided rise in the ground water table.

For the Meadowlands station the maximum run-off usually occurred during the first 6 hr after the intense part of the rain and frequently exceeded a rate of one acre-inch per day. The highest *rate* was 1.60 a-in (acre-inches) on September 6, 1925 when 2.80 in of rain fell in 9 hr. The maximum rate of discharge exceeded one inch per day three times and 0.50 in seven times, while the total discharge exceeded 0.50 in only once (October 12 to 15, 1928, when 0.77 in ran off, following 1.47 in of rain). The highest total discharge during the *growing season* (May to August, inclusive) was 0.31 in on July 26, 1928.

At the Paynesville station the maximum rate of run-off occurred 1 to 4 hr after the beginning of a



FIGS. 3 AND 4 GROUND WATER PROFILES AT MID-POINT BETWEEN TILE LINES AND DAILY PRECIPITATION, AT THE PAYNESVILLE AND WASECA STATIONS

storm, and as near as could be determined from the records, it was within 2 hr after the intense part of the storm. On July 8, 1926, when 2.84 in of rain fell in an hour, the maximum rate of run-off (0.33 a-in per day) occurred within 2 hr after the beginning of the storm. The total run-off for this storm was 0.31 a-in per acre.

Owing to the difference in soil, topography, area, and the design of the system, the Paynesville tile drainage system reached the maximum discharge rate sooner but continued to discharge water longer after a storm than did the Meadowlands tile drainage system.

At Meadowlands the area in the drainage basin is small (7.5 acres), level, and of fairly uniform soil formation, while at Paynesville the area is larger (208 acres) rolling, including many small pockets and swales, and of variables soils formation. Several surface inlets were installed in the depressions at the Paynesville station, thus giving a greater and quicker concentration of the run-off through the tile lines than would otherwise occur.

WHAT CONSTITUTES GOOD DRAINAGE?

The foregoing discussion has shown the great variation between rainfall and run-off and the great influence of the season of the year, especially the growing season, on the amount and rate of accumulation of excess water and the consequent amount and rate of run-off. The next logical step, then, is the consideration of what really constitutes good drainage.

The most important point in the effectiveness of a tile drainage system is the distance between the surface and the ground water table at the mid-point between the tile lines. Rothe[3] suggests 50 cm (20 in) for cultivated crops and 40 cm (16 in) for hay crops. Although this will depend upon the types of crops, their root systems and water requirements, an average value can, as a rule, be used for various types of crops grown in the rotation.

The author has observed that crops will not be injured if the water table at the mid-point is kept one foot or more below the surface at all times, and two feet or more below the surface 75 per cent of the time. Even though the water comes within one foot of the surface but not over the surface, the injury will not be great for most crops if it can be lowered again in a few hours. The grass crops are much more tolerant of water than the ordinary row crops. As a rule the truck crops are the most sensitive to excess water, and therefore should have the most effective drainage system.

Ground Water Measurements. In order to secure evidence of the effectiveness of drainage that might be expressed in physical units, it was necessary to measure the fluctuations of the ground water table. To accomplish this a line of test wells was set, at each of the observation stations, at right angles to the direction of the tile lines. These wells were located at the tile lines, 5 and 10 ft away and at various intermediate distances according to the spacing of the tile lines.

Ground Water Fluctuations. The ground water fluctuations are caused by precipitation, transpiration, evaporation, run-off, and deep seepage. In order for gravity water to be present in the soil, the soil moisture content must be above the capillary capacity. Until enough precipitation has fallen to bring the soil moisture content above this capacity, the ground water table will remain stationary or continue to drop even below the tile lines. However, after the "hydraulic slope" (defined by Schlick as the "head" causing flow toward the tile drains) has become less than 1 to 5 ft in 100 ft, depending upon the soil and the spacing of the tile, the lowering of the ground water table is due to deep seepage alone.

In many cases the permanent ground water table is many feet below the surface. The temporary saturated condition of the surface soil is due to a partially impervious subsoil or to one in which the frictional resistance is so great that it take many weeks for the water to get through. The rate of downward percolation varies greatly depending upon the texture of the substrata. The drop of the ground water table due to deep percolation and to transpiration is sometimes greater than the movement to the tile lines. It is hard to separate the different water movements, as they all work contemporaneously. Better soil drainage, which means greater or more rapid lowering of the water table, gives an opportunity for more vigorous plant growth which in turn transpires more water and opens up the subsoil by root penetration.

Although the roots of most of the ordinary cultivated crops will not penetrate a saturated soil to any extent, they may live for a few days in a saturated soil if the water is moving and does not cover the surface. In case the water comes to the surface and the weather is hot, the plants will generally scald within a few hours. Since the soil immediately above a saturated soil approaches saturation, it is better to design the drainage system so that the maximum height of the ground water table is at least one foot below the surface, except for extreme conditions when it may rise within the first foot zone for a period of only a few hours duration.

The peak height of the ground water table and the daily precipitation are plotted in Figs. 1 to 4.

With the precipitation history, the physical characteristics of the soil, the fluctuation of the water table and the influence thereon of precipitation and plant growth, available as presented in the discussion up to this point, the way

TABLE II AVERAGE RATE OF DROP OF GROUND WATER AT MID-POINT BETWEEN TILE LINES

	Subsoil				Rate of drop in feet per day from surface downward: May 1 to August 31					September 1 to October 15				
Location	Type	Moisture equivalent	Tile spacing feet	Tile depth feet	Maximum, feet	1st 6 in feet	2nd 6 in feet	3rd 6 in feet	4th 6 in feet	Maximum, feet	1st 6 in feet	2nd 6 in feet	3rd 6 in feet	4th 6 in feet
Aitkin		12	200	5.0	0.30				0.30	0.34			0.34	0.23
	Sandy	10	295	4.5	0.18		0.17	0.15	0.15	0.17		0.17	0.15	0.15
	Loam	12	600	4.0	0.18	0.10	0.10	0.10	0.10	General rise				
		10	800	5.0	0.18	0.07	0.07	0.07	0.07	General rise				
Meadowlands		27	60	3.4	0.80			0.67	0.55	1.05		0.62	0.53	0.38
	Silt	27	90	3.4	0.80		0.71	0.50	0.41	0.70		0.48	0.40	0.29
	Loam	27	135	3.4	0.75	0.75	0.55	0.38	0.31	0.65	0.45	0.36	0.30	0.22
Paynesville	Loam	21	100	4.0	0.74			0.64	0.50	1.10		1.10	0.45	0.38
		21	250	4.2	1.02	0.69	0.58	0.35	0.23	0.55		0.55	0.24	0.20
Waseca	Clay	35	45	3.4	2.90	2.04	1.00	0.70	0.60					
		30	125	3.6	1.80	1.06	0.54	0.38	0.31					

is now opened for consideration of suitable drainage procedure and determination of a working formula for tile drainage design.

THE PROPER SPACING AND DEPTH OF TILE DRAINS

Natural Determining Factors. The type of soil, the type of crop, and the climatic conditions are the determining factors in the proper spacing and depth of tile lines. As a general rule the gently rolling lands do not present much of a problem as they have fair natural drainage except in the depressions. In such cases the tile lines are run up the approximate center of these depressions. The flat lands with poor natural drainage are the ones which require a thorough investigation in order to design a system with the proper spacing and depth.

The limiting conditions of this study beyond the author's control have not permitted of a close scientific study of plant development in relation to excess free water in the soil, so that this phase of the problem of tile drainage design is considered to be outside the scope of the present discussion. Therefore, in the following final analysis of the data covered in this study and in the development of a practical rule of design, the author confines the argument to certain soil characteristics which he believes to be the most potent factors governing the effectiveness of any tile drainage system.

The Rate of Drop of the Ground Water at Mid-Point Between Tile Lines. The rate of drop of the ground water at the mid-point varies considerably according to the previous moisture condition of the soil and to the temperature, being very rapid when the subsoil is low in moisture content and warm. (See Figs. 1 to 4). The average rate of drop for each of the first four 6-in intervals for each of the four observation stations is given in Table II. When the subsoil is low in moisture content the greatest movement is downward, while when the subsoil is already saturated, the movement is lateral, and in most cases the lateral movement is much slower than the vertical. In the early spring and late fall when both the soil and precipitation are cold, the movement is much slower, but, at these times, there is no need of having the free water removed so quickly. (See Table II.) A heavy crop on the ground accelerates the drop through transpiration by the plants. Then, too, when the transpiration is great, the reservoir for additional storage of water is rapidly enlarged, as will readily be understood when it is realized that the maximum transpiration for corn is 1/4 in per day. For other grains it is slightly less.

(Concluded in the July AGRICULTURAL ENGINEERING*)*

Unloading Characteristics of Orchard Sprayer Pressure Regulators

(Continued from page 193)

the spray lines are closed, as shown by the curves; and the greater the operating pressure, the greater is this increase.

CONCLUSIONS

1 The factors affecting the unloading characteristics of the standard pressure regulator are (a) the spring constant, (b) the areas of the diaphragm or piston and the valve seat, (c) the valve stem clearance, and (d) the total length of the spring.

2 The velocity of the liquid through the by-pass valve is sufficient, in some cases, to cause a back pressure on the pump, thus preventing the regulator from unloading.

3 The power unit can be unloaded to one-fifth of the power required to operate the spray line (a) if the regulator is in good mechanical repair, (b) if a spring is used that can be compressed a large amount, (c) if the area of the diaphragm or piston is not more than five times the area of the by-pass valve seat, and (d) if the valve-stem clearance is set properly.

4 The relief-valve type of regulator is a good pressure-control device, but increases the horsepower instead of unloading the power unit.

6 The check valve in the standard-type regulator must prevent the liquid from leaking, in order to unload the power unit.

A Philosophy of Abundance

IT IS typical of engineers to seek for Truth, no matter in what strange or hostile guise she may be found. For this reason, then, if for no other, engineers will scarcely be satisfied with allying themselves to the cause of the durable-goods industries on the grounds of self-interest alone. Assailed by doubts of the social justice of the industrial system raised by certain abuses of speculation and finance, by apparent failure of mass purchasing power, by periodic unbalance in the price structure affecting the exchange of goods and services, and by a frequently voiced suspicion that productive capacity is in excess of normal requirements, engineers need to establish a fundamental social philosophy to which they can cling with faith that its validity can and will be justified. Once this philosophy is set up, it should be the duty of engineers to preach it unremittingly so that its wide acceptance will provide the means by which mankind may live more abundantly.

There are many who believe that a philosophy of abundance can be more logically and successfully defended than a philosophy of restricted production. It is this philosophy that engineers should vindicate and disseminate. Upon their knowledge and skill it rests and its broad acceptance in an atmosphere sympathetic rather than hostile to it should lead to wide-spreading growth of standards of living and well-being.

If engineers do not embrace and promulgate the philosophy of abundance they may as well resign themselves to the lean living of the past few years. They cannot of themselves force the acceptance of this principle upon the world, but they can help mightily, and they may as well start by doing everything in their power to revive and stabilize the durable-goods industries, even if they lay themselves open to the charge of self-interest.—Editorial from the June 1934 *Mechanical Engineering.*

HAY CURING: III. Relation of Engineering Principles and Physiological Factors[1]

By T. N. Jones[2] and L. O. Palmer[3]

IN ALL SCIENTIFIC investigations there must be a strict observance of the natural forces, properties, or factors concerned, in order that even a fair degree of success may be attained. Failure to consider these would lead immediately to the assumption that inert matter is dealt with in surroundings that are so fixed as to never be altered by either external or internal conditions. This, of course, is a purely hypothetical case, for all investigations are concerned with substances that possess certain qualities or properties which exert an influence upon the environment and in turn are more or less influenced or controlled by certain factors of this environment.

This is as true perhaps of engineering as of any other branch of science, and it would seem that the agricultural division of this branch would especially benefit by a thorough knowledge and consideration of the laws of nature pertaining to the plant kingdom and to the soil. In recognition of this fact, plant physiology and agricultural engineering have been cooperating at the Mississippi Agricultural Experiment Station since 1931 in an effort to determine the fundamental principles underlying the field curing of forage crops.

One phase of this work deals with the rate of curing of alfalfa hay when handled by different field methods and the corresponding behavior of the stomata as a probable explanation of the results obtained as well as a determination of the factors to be controlled. This matter may be deemed insignificant or irrelevant unless we are aware of the tremendous amount of moisture that plants give off to the surrounding atmosphere by the process of transpiration which is the loss of water in the form of vapor from the leaves and young stems.

Miller[4] found in Kansas that an acre of corn plants transpired during the growing season an amount of water equal to eleven inches of rainfall. Richardson[5] observed that 25 per cent of the total water requirement of alfalfa may be evaporated in three-days' time while in full-bloom stage. This amount based on the water requirement in Colorado over a period of seven years would be 6,263 lb per hour for an acre producing 2,100 lb of dry hay. Assuming that the green hay had an average water content of 70 per cent, the required loss of water to reduce it to field-dry hay with 15 per cent moisture would be 3,850 lb. Therefore, when cut at this stage and on a day favoring rapid transpiration, the hay would reach the field-cured stage within one hour's time, if it could be handled in such a manner as to prevent serious harm to the factors concerned in the natural process of transpiration. This asumption is, of course, absurd in its entirety, but it does indicate the possibility, if not the probability, of more rapid progress if engineering practices within this particular field can be so directed as to aid the natural physiological processes concerned.

Following the work of 1931 as published in AGRICULTURAL ENGINEERING, the procedure was identical except for the time of cutting and the precision in regard to time and method of windrowing. The time of cutting was fixed definitely at 9 a. m. and adhered to without exception, while the periods which lapsed between the time of cutting and windrowing were more accurately determined. The curves shown in Figs. 1 and 2 give the results of three years' work, correlated with all affecting factors.

These figures show a greater loss of moisture for a day's period under all conditions by this more efficient method of handling than was true in the first year's work. The difference between the minimum moisture content reached for the first day in the different positions for these two cases cited was: 7 per cent for the swath, 9 per cent for the single and 1.5 per cent for the double windrows raked as cut, 6 per cent for the single and 5.5 per cent for the double

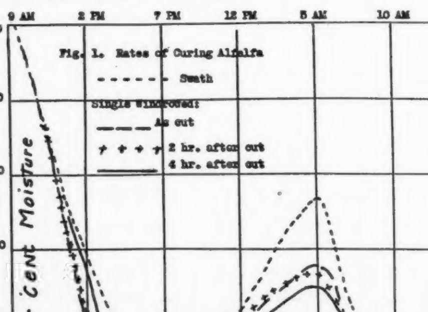
[1]Third paper of a series setting forth the results of three years' research in hay curing at the Mississippi Agricultural Experiment Station. Parts I and II were published in the August 1932 (Vol.13, No. 8) and June 1933 (Vol. 14, No. 6) AGRICULTURAL ENGINEERING, respectively. This paper was presented at a meeting of the Southern Section of the American Society of Agricultural Engineers helds at Memphis, Tennessee, January 1934.

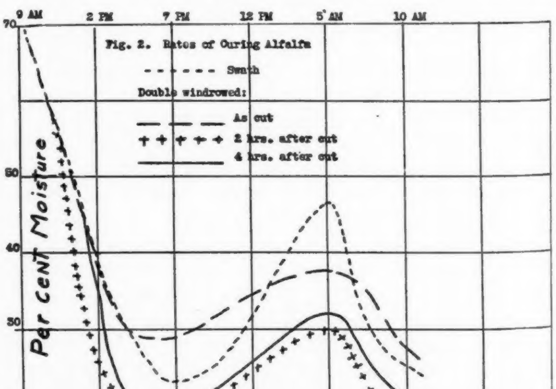
[2]Agricultural engineer, Mississippi Agricultural Experiment Station. Assoc. Mem. A.S.A.E.

[3]Plant physiologist, assistant in agricultural engineering, Mississippi Agricultural Experiment Station.

[4]Miller's "Plant Physiology" (first edition), p. 313.

[5]Richardson, A.E.V., 1923: The water requirement of farm crops. Jour. Dept. Agr. Victoria.





windrows raked 2 hr after cut, 6.5 per cent for the single and 4.5 per cent for the double windrows raked 4 hr after cut.

The hay that was double windrowed 2 hr after cut surpassed all other tests in moisture loss for the day by reaching the low level of 18.5 per cent by 6:00 p. m., which was 9 hr after cut. Next in order was the double windrow raked 4 hr after cut which reached 19.5 per cent at the end of the same period. The double windrow raked as cut lost less moisture than any of the other tests, as shown in the first paper of this series.

In the single windrows there was a difference of only 2 per cent in moisture content at the end of the day for the hay raked at the different intervals. This existing difference between the hay windrowed as cut and that windrowed 2 hr after cut is in favor of windrowing as cut as contrasted with 1931 results favoring windrowing 2 hr after cut. That which was windrowed 4 hr after cut was midway between these two.

As an improvement over the methods used in making the physiological study as described in the first and second papers of this series, a Loica camera was purchased so that photomicrographs might be obtained to replace the Camera-lucida drawings of the stomata. The technique used in the preservation of leaves and the actual making of mounts for the study were the same as described in the second paper. With the aid of the special Loica attachment the highly magnified epidermis containing the stomata were photographed without any process of staining to introduce the danger of distortion. Dupont ¼-speed Panchromatic film with process development and a contrast paper gave prints which showed clearly the outline of stomatal pores and shrinkage of protoplasm within the epidermal cells as dehydration progressed. The 35 mm negative film can be enlarged to produce a print 8 by 10 in, if desired. The accompanying prints show the epidermis of the leaf enlarged 900 times actual size. The photomicrographs obtained are considered more accurate and authoritative, since they eliminate all doubt of any personal element or interpretative error in the graphic representations.

Results of this work as shown by the accompanying prints indicate that at the end of 2 hr in the swath the stomata are practically closed and plasmolysis of the cell content is rapidly advancing. However, when the hay is double windrowed at the end of this two-hour period, the stomata reopen. This reopening of the stomata is accompanied by an increase in the rate of moisture loss following windrowing (Fig.2).

As stated in our first paper, the greater part of the plant moisture is lost through the stomata of the leaves. As shown in Fig.3, the leaves of alfalfa lose moisture much more rapidly than do the stems when the two are separated and allowed to dry separately, thus going parallel with the theory that the leaves are especially adapted to the loss of moisture. When the hay remains in the swath, a large percentage of the leaves are exposed to the direct rays of the sun, and the moisture loss is much more rapid than the normal renewal of moisture from the stem. Consequently, there is a shortage of moisture in the leaf, and as the cell walls bordering on the intercellular air passages become dry, the remaining water retreats to the cell cavities, thereby causing the protoplasmic content of the cells to shrink, similar to that for the ordinary epidermal cells. As this shrinkage occurs the surface tension of the remaining water increases, while the vapor pressure decreases, thereby resulting in a serious check of evaporation from the leaf. The guard cells begin to lose their rigidity, due to dehydration, and the size of the stomatal pore decreases until almost complete closure results when the water content of the leaf falls below the working margin.

When the hay is double windrowed after a two-hour period in the swath, the temperature surrounding the leaves inside the windrow gradually falls and the relative humidity rises. Tests in 1932 showed that the temperature inside the windrow was 5 to 8 deg (Centigrade) lower in the double windrow 3 hr after cut than in the swath, while the relative humidity was 10 per cent higher in the double windrow than in the swath at the same time. A combination of these factors favor a temporary check in the moisture loss from the leaves sufficient to permit the cell walls bordering the air spaces of the leaf and the stomatal chambers to again reach the saturation point and for the guard cells to become more turgid and begin reopening. After this takes place it seems that the partially opened stomata, and the lower temperature, and the higher relative humidity of the air surrounding the leaves tend to keep the leaf functioning somewhat in its natural capacity, so that the water of the stem has a freer outlet for evaporation; thus the total moisture content of the plant is reduced rather than the leaves only, as was true to a great extent in the swath. These factors in conjunction with reduced light intensity favoring the preservation of chlorophyl, and a more uniform drying of stems and leaves favoring the retention of leaves, served as a basis for the recommendation of windrowing. In all cases where the hay was windrowed after a definite period in the swath, there was an increase in the rate of moisture loss over

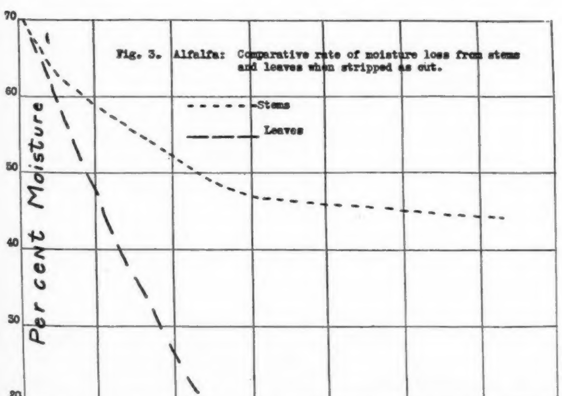


Fig. 3. Alfalfa: Comparative rate of moisture loss from stems and leaves when stripped as cut.

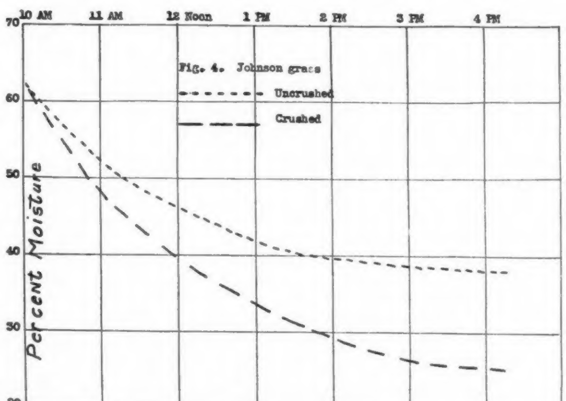


Fig. 4. Johnson grass

PHOTOMICROGRAPHS SHOWING THE BEHAVIOR OF STOMATA OF ALFALFA LEAVES AFTER CUTTING. (LEFT) TAKEN FROM GREEN PLANTS AS CUT, AT 9:00 A.M. (MIDDLE) TAKEN FROM SWATH 2 HR AFTER CUTTING (11:00 A.M.). (RIGHT) TAKEN 3 HR AFTER CUT (12:00 N) FROM DOUBLE WINDROW (RAKED AS CUT)

that of the swath, even within the first hour after windrowing.

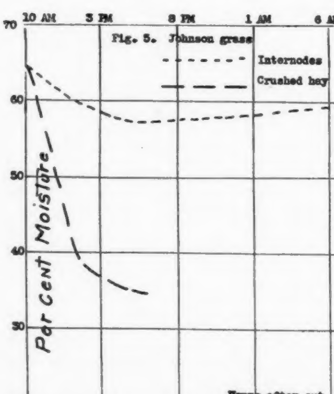
Therefore, the practice of windrowing 2 hr after cut for a double windrow, and as cut for a single windrow, considerably prolongs the natural physiological process of transpiration, resulting in hay with a lower moisture content, better color, and more leaves at the end of a day's curing.

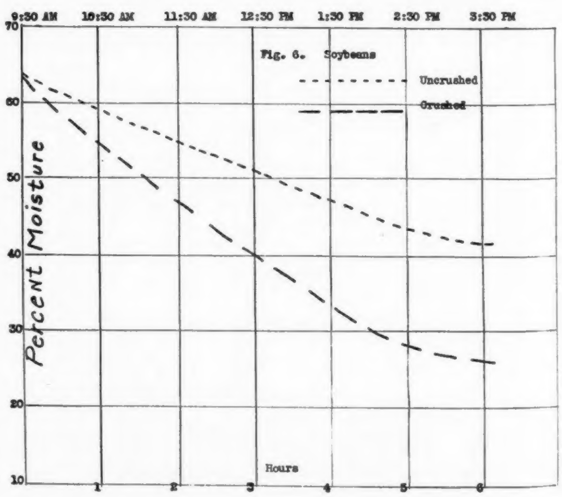
In the single windrow which was raked as cut there was probably sufficient protection from the sun to prevent a complete closure of the stomata, while at the same time the roll of hay was not so compact or dense as to prevent a fair degree of aeration, thereby removing the moisture from the roll almost as rapidly as it was transpired from the leaf. When windrowed 2 and 4 hr after cut, however, the decrease in temperature and increase in relative humidity surrounding the leaf seem to be insufficient to parallel the behavior which occurs in the double windrow, as shown by a comparison of Figs. 1 and 2. The difference in moisture content of these two cases is within the range of experimental error.

In an effort to further hasten the process of curing hay plants, an experimental machine for crushing was developed and used with marked results. For instance, Johnson grass that was cut and crushed by this machine at 10:00 a. m. had reduced to 25 per cent moisture at the end of a 7-hr period, whereas the uncrushed hay contained 37 per cent at the end of the same period, a difference of 12 per cent moisture (Fig. 4). This period terminated at 5:00 p. m., and at the 25 per cent moisture content the crushed hay could safely have been stored in bulk in the barn. By cutting and crushing the hay an hour or more earlier in the day, the possibility of curing the Johnson grass in one day is almost a certainty. This machine which is now being rebuilt is designed to work as an attachment to the tractor mower. Therefore, an extra operation is not necessary for crushing the hay.

As stated in the first article, the difference in the type and size of stems of Johnson grass and alfalfa probably accounts for the more favorable response of Johnson grass to the crushing process. The curves in Fig. 5 show very clearly the impervious nature of the stem wall of Johnson grass, since the internodes with the sheath removed lost only 7 per cent of their total moisture by the end of 7 hr. The amount of water which passed out through the stem wall and through the cut end was not great, as shown by the curves, but the lateral or longitudinal splitting of the stems by crushing gave a rapid increase in moisture loss which totaled 29 per cent of its original moisture content at the end of the 7-hr period. These experiments were conducted on different days, but the data were correlated to the same climatological basis.

Soybeans crushed with this machine reached a moisture content of 27 per cent at the end of 6 hr after cutting and crushing, while the uncrushed hay still contained 42 per cent moisture at the end of the same period (Fig. 6). These tests were made in October after the days were considerably shortened and the temperature was below the summer average. Therefore, with a longer day and higher temperature of the normal haying season, commercially dried





soybean hay might well be expected as a result of crushing.

SUMMARY

1. The practice of windrowing alfalfa hay aids a continuation of the natural physiological process of transpiration, resulting in a greater moisture loss for a day's period.

2. Double windrowing two hours after cut furnishes hay with a better color, larger percentage of leaves and a lower moisture content at the end of the day.

3. Data indicate that the leaf of alfalfa plants aid greatly in lowering the moisture content of the entire plant.

4. Photomicrographs showed a reopening of the stomata following windrowing two hours after cut.

5. The process of crushing large-stemmed hays such as Johnson grass and soybeans will permit a needed change in methods and time required in curing.

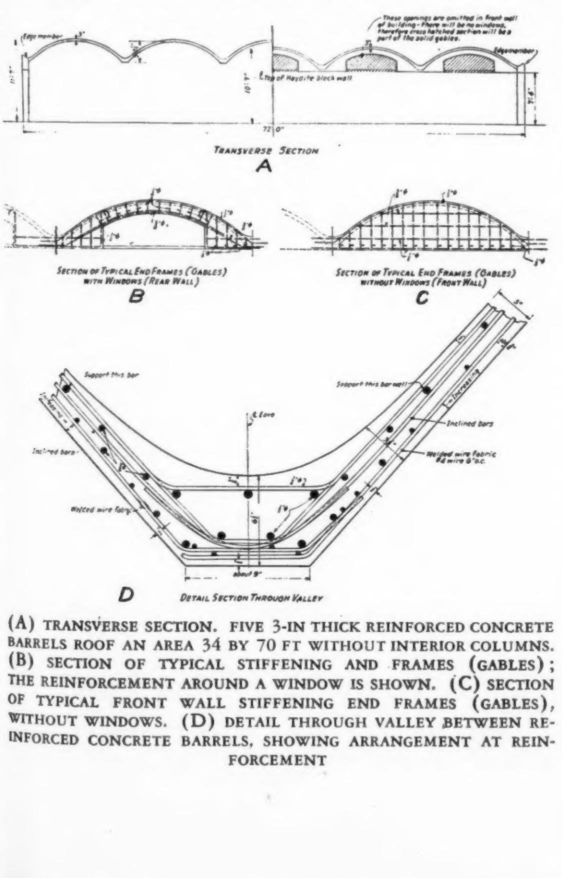
AUTHOR'S NOTE: The field experiments were conducted at the Alfalfa Station at West Point, Mississippi.

Reinforced Concrete Shell Roof Construction on Modern Dairy Barn

FOR THE FIRST time in this country the Zeiss-Dywidag system of roof construction is used on a farm building. Brook Hill Farm at Genesee Depot, Wisconsin, in cooperation with Starline Inc. of Harvard, Illinois, use this roof construction on the stable portion of their exhibition building at the 1934 Chicago World's Fair. A herd of 30 pure bred Wisconsin cows, housed in the stable, will produce certified Vitamin D milk which the public will see as it passes from cow to bottle.

The Zeiss-Dywidag system originated in Germany and has been used extensively in Europe and South America for roofing structures where a large area of unobstructed floor space is required. The economy, fire-safety, and practicability of the construction already demonstrated led to its adoption for the barn of the Brook Hill Farm exhibit.

The outside dimensions of the barn are 36 by 72 ft. Concrete masonry walls support the roof, which consists of five standard barrels, each 14 by 34 ft. The stiffening



(A) TRANSVERSE SECTION. FIVE 3-IN THICK REINFORCED CONCRETE BARRELS ROOF AN AREA 34 BY 70 FT WITHOUT INTERIOR COLUMNS. (B) SECTION OF TYPICAL STIFFENING AND FRAMES (GABLES); THE REINFORCEMENT AROUND A WINDOW IS SHOWN. (C) SECTION OF TYPICAL FRONT WALL STIFFENING END FRAMES (GABLES), WITHOUT WINDOWS. (D) DETAIL THROUGH VALLEY BETWEEN REINFORCED CONCRETE BARRELS, SHOWING ARRANGEMENT AT REINFORCEMENT

diaphragms in the end gables and the beams at the outer edges of the end barrels bring the eaves of the roof flush with the outside of the 12-in thick hollow walls.

Steel forms were used for the gable diaphragms and the outer edge beams. Steel ribs supported the barrel forms. The steel units were standardized so they may be used repeatedly on similar structures.

The arched steel ribs were tied against spreading by tension rods made adjustable by turnbuckles. They were spaced 3 ft 6 in apart, and were supported by curved steel beams running lengthwise of the barrels. The curved beams were required because the roof was given a double curvature to increase the clearance over the center aisle through the barn. The double curvature is not essential to the action of the roof, and this job, as far as known, is the first application of double curvature to a barrel shell roof.

Over the steel ribs, 1-by-6 in sheeting lumber spaced about 4 in apart was laid to support 4-ft wide plywood panels. By using plywood a smooth under surface was obtained, and the forms were quickly erected as very little cutting and fitting was required.

Forms for only three barrels were constructed. After the concrete had hardened sufficiently to permit removal of the forms, two sets were shifted to the position of the remaining two barrels.

The reinforcement for the barrels proper was relatively light; 1/4-in, 3/8-in, and 1/2-in bars were distributed in accordance with the intensity of the tensile stress. The thickness of the barrels was 3 in at the crown and only slightly more at the springings. The 3-in thickness was in excess of that required for the load and span, but was provided to give the roof added insulating value. Ordinarily corkboard or other insulating material will be used on the under side of the barrels, but this was deemed unnecessary because the building is to be used only during the summer months.

One day after placing the concrete, the roof was waterproofed with a coat of a special material. It also served the purpose of sealing the mixing water in the concrete, insuring satisfactory curing. The under side of the barrels was painted to harmonize with the interior treatment of the whole structure.

Shell vaults offer a solution to the problem of economically roofing buildings of large area with concrete. This advancement in reinforced concrete design substitutes a shell structure subjected only to direct tensile and compressive stresses for beams, frames, and arches which must resist bending stresses and are therefore limited as to span length. The thin roof cover formerly supported on rafters, purlins, and heavy trusses becomes self-supporting.

Water Penetration in Hardpan Citrus Soils[1]

By Colin A. Taylor[2]

DUE TO THE FACT that moist soil can be readily compacted, there has been a gradual development of hardpan in orchards where cultural operations are carried on when the soil is moist. The degree of compaction depends on the soil type, the relative wetness of the soil, and the traffic load it must bear. All soils are affected, but the effect is least noticeable with sand and much more marked with loams and clay loams. Plow sole may be formed very quickly on these latter soils, and they are sometimes referred to as "hardpan" soils, the reference being to the dense layer of soil just below the usual depth of cultivation. The pressure of the hardpan or plow sole soon becomes apparent in a noticeable reduction in the ability of the soil to absorb water.

When an orchard is set out on new land, very little trouble is ordinarily experienced in getting irrigation water into the ground. But often, quite early in the life of the grove, it is noticed that the soil takes water less readily. The same head of water must be spread out into more and more furrows and held in the furrows for increasing lengths of time. As the plow sole develops, the penetration of water becomes more and more irregular, and it is then very difficult to wet the soil uniformly. As the trees mature, traffic is centered more nearly midway between tree rows, and the soil under the spread of the tree is left uncultivated. Wide differences develop in the ability of different areas to absorb water, and the efficiency of irrigation may become very low. The efficiency of irrigation is defined as the percentage of the water applied that appears as soil moisture within the root zone of the crop.

If we consider the problem solely from the standpoint of water economy, it can be shown that this phase of the hardpan problem is of vital concern to all of those connected with the irrigation of citrus orchards. A very large percentage of the citrus acreage on loam and clay soils is furrow irrigated, and it is a matter of common observation among irrigators that furrows next the trees "take the water," while in the furrows midway between the rows a little water goes a long ways. In Table I, some data are presented that bear out this statement.

TABLE I. Rate of Absorption of Water in Irrigation Furrows in 30-Year-Old Naval Orange Grove on Yolo Gravelly Loam, Corona, California, October 31, 1933

Absorption of water in 360 feet of furrow

Row	Furrow number				
	1	2	3	4	5
	sec-ft	sec-ft	sec-ft	sec-ft	sec-ft
3	0.0080	0.0015	0.0017	0.0012	0.0045
7	0.0025	0.0013	0.0015	0.0020	0.0050
17	0.0040	0.0007	0.0015	0.0025	0.0073
27	0.0032	0.0017	0.0015	0.0010	0.0020
29	0.0060	0.0020	0.0017	0.0007	0.0028
Average	0.0047	0.0014	0.0016	0.0015	0.0043
Average of furrows Nos. 1 and 5			0.0045 sec-ft		
Average of furrows Nos. 2, 3, 4			0.0015 sec-ft		

These tests were taken in an orchard at Corona in which the plow sole would not ordinarily be considered bad. The trees are vigorous and have excellent root systems. The yield is over 700 field boxes per acre. Yet the efficiency of irrigation is low when considered as the percentage of water applied that appears in the root zone. How could it be otherwise with such variable absorption rates as shown in this table? The highest absorption rate shown is 0.0080 sec-ft in 360 ft of furrow and the lowest rate 0.0007 sec-ft —a ratio of nearly 12 to 1. Five furrows are used in this grove, and furrows Nos. 1 and 5 pass within 6 ft of the tree and may be termed "tree" furrows. The average absorption in these "tree" furrows was 0.0045 sec-ft, the highest rate 0.0080 sec-ft and the lowest 0.0020 sec-ft—a ratio of 4 to 1.

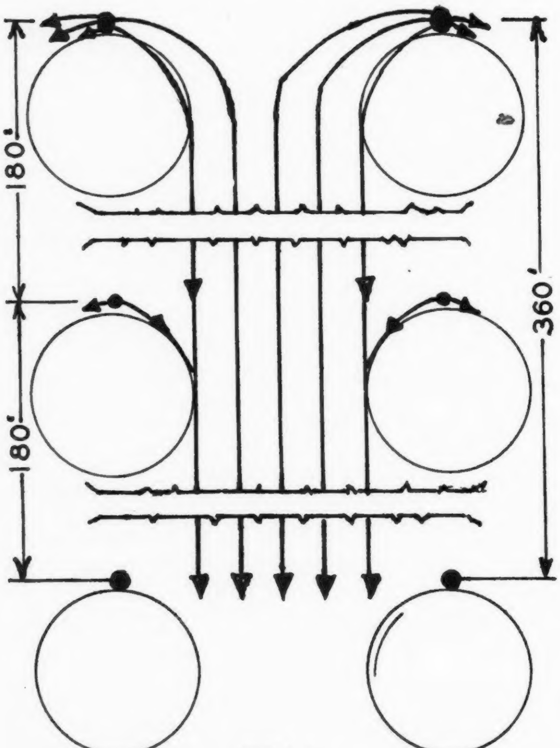


FIG. 1

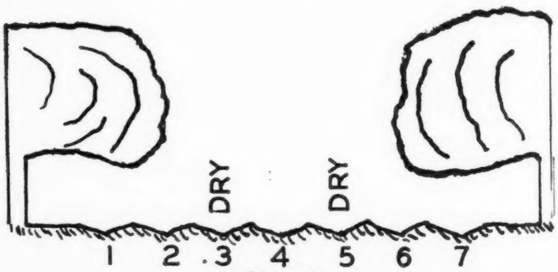


FIG. 2

FIG. 1 FURROW IRRIGATION SYSTEM. FIG. 2 CROSS SECTION OF SEVEN-FURROW SYSTEM WITH 3-TO-1 SIDE SLOPE

[1]Paper presented at a meeting of the Pacific Coast Section of the American Society of Agricultural Engineers, at Pomona, Calif., November 1933.

[2]Assistant irrigation engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Mem. A.S.A.E.

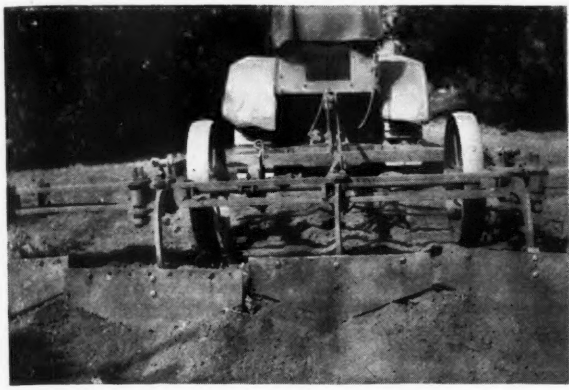


FIG. 3 GRADER-BLADE ATTACHMENT FOR LAYING OUT FURROWS WITH 3-TO-1 SIDE SLOPE

FIG. 4 FURROW SWEEPS USED FOR THE CONTROLLING OF WEEDS IN THE FURROWS

In the remaining furrows, Nos. 2, 3, and 4, the average absorption rate was 0.0015 sec-ft, the highest 0.0025 sec-ft, the lowest 0.0007 sec-ft—a ratio of nearly 4 to 1.

Noting the different absorption rates in the "tree" furrows as compared to the center furrows, a logical division is to run these groups separately. From Table I, it would appear that water should be held in the center furrows three times as long as in the "tree" furrows.

A still further improvement can be had by shortening the length of run for the "tree" furrows. The variation in absorption rates shown in Table I are for furrow runs 360 ft long, and besides the differences shown there is the variation in penetration along each individual furrow to consider. Shortening the length of furrow is most effective in increasing the efficiency when the soil takes water readily and less so when the absorption rate is low. When the absorption rate is high as in the "tree" furrows, there is a relatively large volume of water near the head of the furrow, but the wetted contact area decreases rapidly as the distance from the head stand increases. A new pipe line might be laid across the grove midway of the length of the present furrows but designed to deliver water to the "tree" furrows only. The "tree" furrows will then be 180 ft long and the three center furrows will continue 360 ft long as at present. This should increase the efficiency of irrigation without increasing the labor cost of irrigating. The proposed lay-out is shown in Fig. 1. An increasing number of growers recognize the variations that occur between furrows and are now testing the penetration of water at the end of each furrow before turning off the water.

If the difficulties arising from plow sole were solely a matter of water penetration, we might, by careful attention to the irrigation, overcome them. But poor water penetration is also associated with poor aeration. The citrus tree is shallow rooted and does best on open, well-aerated soils. In groves with a hardpan, we usually find few roots under the hardpan and the best root development in under the tree away from the cultivated area. Lateral penetration in from the "tree" furrows to the active feeder root areas is in many groves the chief source of sustenance for the tree, and in such groves the elimination of the plow sole is certain to result in improving the vigor of the tree and increasing production.

A cooperative study on the relation of irrigation to the yield and quality of lemons is now under way in southern California by the Bureaus of Agricultural Engineering and Plant Industry of the U. S. Department of Agriculture. The Division of Irrigation of the Bureau of Agricultural Engineering is conducting the irrigation work, and we have given some attention to the hardpan problem during the past four years. A cultural program has been worked out that calls for a minimum amount of cultivation and traffic over the soil. Broad shallow furrows are used with side slopes of about three to one. The furrows are laid out in the spring and left for the summer. Seven furrows have been used as shown in Fig. 2.

The furrow spacing is 28 in so that furrows Nos. 3 and 5 are 56 in apart, which is the standard tread distance. These two furrows are left dry and designated as wheel furrows. All wheel traffic resulting from fertilizing, picking, spraying, firing, etc., is confined to these furrows. We are in this way setting aside these two narrow strips of soil for the wheel traffic, and with the furrows for a guide it stays there instead of meandering around and eventually compacting a wide strip of soil in each lane. When the furrows were laid out last year, we simply attached a grader blade in back of the ordinary furrowing-out shovel as shown in Fig. 3.

This year furrow sweeps were designed and constructed for the purpose of controlling weeds in the furrows with the least possible disturbance to the ridges between the furrows. These are shown in Fig. 4. The sweeps are drawn through the furrows just before each irrigation when the soil is dry. The cutting depth may be as little as one-half inch or as deep as desired.

In the late fall, bulky organic fertilizer is spread in the furrows and the grove disked lightly to cover the organic material enough to allow for decomposition during the winter. The minimum of disking is planned, as it is desired to conserve all the feeder roots possible to absorb moisture for use by the tree during the high north winds that are apt to occur at this season of the year. Next spring the soil will be disked as soon as it is dry enough and the furrows again laid out for the following irrigation season.

With this program we accomplish several beneficial results. There is a minimum of cultivation and soil disturbance. The three to five inches of loose soil that was formerly cultivated and used to form furrows throughout the summer is now available to the feeder roots. The roots of the small weeds that start after each irrigation improve the soil structure and the activities of worms aid in its further improvement. This structure is not repeatedly broken down during the summer under the new program. Traffic is confined to definite lanes and kept off moist soil. The plow sole or hardpan is thereby reduced to a minimum and better penetration of water and higher efficiency in irrigation should result as well as an improvement in the vigor of the trees.

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RAYMOND OLNEY, Editor
R. A. PALMER, Associate Editor

Labor-Saving: Misnomer or Not?

IN THIS ISSUE are letters from Messrs. Davidson and McKibben challenging the proposal to adopt a substitute for the term "labor-saving" as suggested last month in these columns. Though received and published as letters, they might with equal propriety have taken the form of signed editorials.

This clash of friendly opinion—it happens that, though the two engineers informally quoted last month were not identified, all four are personal friends—will serve a useful purpose if it provokes quantitative economic studies to remove the question from the realm of intelligent opinion to that of demonstrated fact.

Mr. McKibben points out that though the *result* of machinery usage may include labor-shifting, the *motive* for its adoption is or should be a net gain in value or reduction in cost per unit of product, which ultimately must mean a saving in human effort. The question then is whether the machine should be named on the basis of motive, or according to result; and, in the latter case, how much weight should be assigned to diversion and to net decrease, respectively.

We believe it important to establish and emphasize the difference between (1) the machine's influence on labor consumed in a specific operation or unit of product and (2) its total, ultimate effect on the employment of and reward for human service. There is a tendency to assume that (1) and (2) move together, and this assumption no doubt is to blame for much of the talk, heard in recent years, about labor being the victim of the machine. Our own opinion, admittedly subject to proof, is that while (1) has seemed to decrease steadily during our period of observation, say, a generation, it has been accompanied by (2) remaining unchanged or increasing slightly.

While this view, right or wrong, does not bear precisely on the question of labor-saving as a misnomer or otherwise, it does bear on the social value of machinery. And this social value is rightly enough uppermost in popular opinion, however wrong such opinion may be in its analysis of costs and benefits. Far from seeking to stifle this clash of opinion among friends and experts, we believe it should be continued, bringing to bear more and more statistical evidence.

"Labor-Saving: A Misnomer"

To the Editor:

THE EDITORIAL in the May AGRICULTURAL ENGINEERING, entitled "Labor-Saving: A Misnomer," has been read with considerable interest.

It is recognized by all that, in the application of power to farm operations in the use of machines, some of the labor originally used in agricultural production has been shifted from the farm to the factory. It might be worth while to make a careful study of just how much labor has been shifted in this way. I believe, however, that it would be unfortunate to assume that there has been no reduction or labor saving, because it is on the premise of making labor more effective that the agricultural engineer justifies his existence as far as his interest in power problems and the use of machines is concerned. The principle is that the fewer people we have producing food and raw materials used for food, shelter, and clothing, the more people will be available for producing commodities and services which contribute to general well-being.

A closer survey of the situation would indicate that a very large contribution to human welfare has been made in this connection. It is recognized that approximately 25 per cent of the population is now directly engaged in agriculture. It is not so many years back when the proportion was directly reversed and 75 per cent of the population was directly engaged in agriculture. Would anyone suggest that the difference in these percentages, or 50 per cent of the total population, is now engaged in producing equipment directly and indirectly for the farm?

J. B. DAVIDSON

To the Editor:

IN CONNECTION with the editorial, entitled, "Labor-Saving: A Misnomer," which appeared on page 174 of the May AGRICULTURAL ENGINEERING, I wish to offer the following suggestions. Please keep in mind that this letter is submitted as a basis for friendly discussion. It is not necessary that you publish only what all members of our Society agree with, and it is equally true that the members need not agree with all that is published in our journal, because to accomplish such agreement it would be necessary either to have a very dull journal or a very dead Society.

It is the judgment of many engineers that machines have been and are used primarily for the following three reasons: (1) to decrease the time required for a given accomplishment (time saving), (2) to decrease the human energy required for a given accomplishment (work saving), and (3) to improve the quality of the work accomplished.

Machines which decrease the time and human energy required for a given accomplishment have been called "labor saving." While there may be a better term for the idea involved, the connotation of the term "labor saving" is certainly sound and very descriptive. Also, any machine whose design, manufacture, merchandizing, and transportation requires as much labor as it saves, probably has a very doubtful future.

While it is true that most machines do divert or shift labor, possibly even adjust labor, in practically all cases this is only a secondary result; in fact, in most cases labor and

management must make adjustments in order to reap the benefit of the machines. Labor is adjusted because of the introduction of the machine, rather than the machine being introduced to adjust labor.

It would seem that as engineers, we should face the facts and maintain our loyalty to the truth. If the principal characteristic of a machine is its labor-saving capacity, it should be called a labor-saving machine, or some term with a similar meaning. If, on the other hand, labor adjusting is the primary characteristic of any machine, then such a machine could justly be called a labor-adjusting machine. In this connection I think it might be well for those who wish to substitute the term "labor adjusting" for "labor saving" to supply us with a list of machines which have been widely accepted and which were primarily introduced because of their labor-adjusting characteristics.

If labor-saving machines are actually a detriment to society, changing their names will not help. If, as we agricultural engineers have always thought, they are a benefit to society, then let us do what we can to so manage these machines and do what we can to help society so manage itself that it may reap a maximum benefit from such labor-saving machines. — E. G. McKibben

To the Editor:

BEFORE DECIDING whether or not "labor-saving" is a misnomer, it might be well to look into some of the oft-cited statistics on the alleged efficiency of the farmer, and see whether they mean exactly what we have been assuming them to mean. In recent years it has become a habit to mention that forty, or a hundred, or two hundred years ago there was 50, or 75, or 90 per cent of our population living on the land and engaged in agriculture as compared to the 25 or 30 per cent in the present or immediate past. It seems to be taken for granted that the trend is simply a matter of increased efficiency in farming methods and machines.

With the warning that the figures above and those to follow are not statistically exact, but merely rough assumptions to exemplify the argument, let us hark back to the time, perhaps in great-great-grandfather's day, when 90 per cent of the population lived on farms and was classified as actively agricultural. Suppose that we list their major activities and appraise their social contribution. We would find that the farmers of that era

1 Then, as now, produced raw food and clothing materials for 100 per cent of the people

2 Manufactured clothing (in the farm home) for about 90 per cent of the people

3 Produced fuel (wood) for at least 90 per cent of the people

4 Produced artificial illumination (candles) for probably 99 per cent of the population

5 Produced both power units (animals) and fuel (feeds) for some 95 per cent of total power usage, including transportation

6 Produced with farm labor perhaps 50 per cent of all building materials

7 Did 100 per cent of the processing of dairy products, mainly manufacture of butter and cheese

8 Performed all slaughter and processing of meat products for at least 90 per cent of the population

9 Performed or obviated the processing of some 95 per cent of all other foods except the simple milling of cereals

10 Transported to consumer, retailer, or local miller, probably 90 per cent of all foods and fuels

11 Performed retail distribution of an unknown, but certainly large percentage of commodities then used

12 Obviated the major part of wholesale distribution as we now know it

13 Performed or obviated most of the personal salesmanship, advertising, and sales promotion, including printing.

The 25 per cent or so of our population now classified as actively agricultural still perform several of these contributions to social living, but in amounts so small as to be statistically unimportant. We probably think of the farmer as performing only, or mainly, function No. 1—the production of raw food stuffs and clothing materials. It seems not only unfair to our ancestors but no credit to our own thinking to assume that the difference between 90 per cent and 25 per cent is a measure of farming efficiency.

Before we make any egotistical comparisons between the efficiency of our methods and machines and those of great-great-grandfather, we must add to the present percentage of farm population a proper proportion of those other industrial and trade groups which have taken over the jobs which he did, and his modern successors do not. Again making roughly illustrative assumptions, we should add to the present farm people the population engaged in

1 About 90 per cent of textile industries and garment making

2 At least 90 per cent of industry devoted to domestic heat and light, such as coal mining; gas manufacture; petroleum drilling, piping, and refining; electric generation and distribution; and making equipment therefor

3 Some 95 per cent of production of power plants and fuel—steam, electric, and automotive—for power used in industry and transportation

4 Perhaps 50 per cent of structural materials production

5 Practically 100 per cent of the dairy products industries

6 Some 90 per cent of the stockyards and meat-packing industries

7 About 95 per cent of canning, freezing, packaging, cold storage, and other industrial food-processing (again excluding simple milling of cereals

8 Probably 90 per cent of railway and highway transportation of feeds, foodstuffs, and domestic fuels

9 A large percentage of retail distribution

10 A major part of wholesale distribution

11 Most of sales representation, advertising, sales promotion, and printing.

Probably even this imposing array is not a complete list of the trades which, in greater or lesser measure, must be added to modern agriculture to embrace the contributions to social living which were made by farm families when they comprised 90 per cent of the population. If and when we can complete the list and insert accurate values for these rough assumptions, then the sum of them, plus the existing farm percentage of population, will afford an index to the overall efficiency of the modern equivalent of the old-time farmer.

Taking the present farm population at 25 per cent and comparing it with the 90 per cent point, 65 per cent of our total population has been displaced from agriculture. Of this 65 per cent it seems to this writer probable that more than half has been shifted to the occupations listed above as compensating for the greater specialization in agriculture, and that less than half has been "labor-saved." If so, those who prefer the term "labor-adjusting" or "labor-shifting" may find firm ground on which to contend their case.

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NEWS

Canadian Agricultural Engineers to Meet

THE CANADIAN Section of the American Society of Agricultural Engineers, which also functions north of the international boundary as the Engineering Group of the Canadian Society of Technical Agriculturalists, will meet at the time of the annual convention of the latter organization to be held this year, June 25, 26, and 27, at Macdonald College, Quebec.

This meeting occurs the week following the 28th annual A.S.A.E. meeting at Detroit, and the Canadian group of agricultural engineers extends a cordial invitation to those attending the A.S.A.E. meeting to cross over to Canada for their meeting.

The agricultural engineering program at the C.S.T.A. convention is still in the preliminary stage, but the following contributions have already been arranged, which promises a program of unusual interest for agricultural engineers:

1 "The Economics of Farm Mechanication," by Arnold P. Yerkes, International Harvester Company.

2 "History of Drainage Extension in Ontario," by F. L. Ferguson, Ontario Agricultural College.

3 "Forced Ventilation of Dairy Barns," by W. C. Harrington, extension agricultural engineer, Massachusetts State College.

4 "Storage Houses for Apples," by C. I. Gunness, professor of agricultural engineering, Massachusetts State College.

5 "The Effect of Underdrains on the Water Table of Some Quebeck Soils," by Robert Millinchamp, agricultural engineer, Macdonald College.

6 "Electric Heating of Hotbeds," by W. G. Mainguy, Shawinigan Water and Power Company.

7 "Mechanical Milk Coolers on Farms," by J. W. Purcell, Hydro Electric Power Commission.

8 "Recent Improvements in the Design and Construction of Agricultural Machinery," by G. T. M. Bevan, chief engineer, Massey-Harris Company.

The open sessions of the C.S.T.A. meeting will, in addition to business matters, deal with the trend in marketing legislation. The opening of the new Parisitology Institute will take place on Wednesday afternoon, June 28, and on Thursday, June 29, the convention attendants will spend the day at Oka Agricultural Institute, the Trappist Monastery near Montreal. Incidentally, the latter is a very interesting place as the monks do practically all their own construction work, being skilled carpenters and machinists and have a considerable amount of equipment. It is said that they have one of the largest barns in Canada. On Friday and Saturday of the week on which the convention is held there will be a motor trip to Quebeck City. Transportation will be provided for A.S.A.E. members who arrive at Macdonald College by train. The Quebec Department of Agriculture will arrange special cars to take care of visitors at the convention.

Pacific Coast Section in Joint Meeting

NOT ONLY will the Pacific Coast Section of the American Society of Agricultural Engineers meet with the 94th conference of the American Association for the Advancement of Science to be held at Berkeley, California, June 18 to 23, and participate with thirty other scientific organizations in the conference, but also the names of several A.S.A.E. members are featured on the program of the conference.

At the aeronautics-hydraulics Meeting, sponsored jointly by the Institute of the Aeronautical Sciences and the American Society of Mechanical Engineers, F. C. Scobey, U.S.D.A. Bureau of Agricultural Engineering, will present a paper, entitled "Open Channel Flow," and L. S. Wing, engineer, California Farm Bureau Federation, will present a paper, entitled "Pump Engines and Motors," the discussion of which will be led by B. D. Moses, University of California.

In a joint meeting of the Hydrology Section of the American Geophysical Union and the A.S.A.E. Pacific Coast Section, M. R. Lewis, U.S.D.A. Bureau of Agricultural Engineering, will preside at one of the sessions, at which a paper, entitled "Transpiration and Evaporation from Areas of Natural Vegetation," by Colin A. Taylor, also of the Bureau of Agricultural Engineering, will be presented, followed by supplementary data and discussion by Major O. V. P. Stout, an Honorary Member of the Society and the first McCormick medalist.

Necrology

Kay Iverson Church, who for seven years was employed as a field agricultural engineer of the Portland Cement Association in the Kansas City territory, was instantly killed in an automobile accident recently near his home city, Wichita, Kansas.

Mr. Church was born at Haddam, Kansas, January 15, 1898, and graduated from the agricultural engineering course at Kansas State College in 1923; he obtained a professional degree from the same institution in June 1927.

Upon graduation in 1923 he entered the employ of the Russell Machinery Company's branch at Wichita, in charge of the repair sales department, assisting also in office sales of new and used machinery. In January 1925 he became associated with the Kansas City office of the Portland Cement Association as field agricultural engineer, devoting his attention to improving and extending the uses of concrete on farms in Kansas, which position he held until about three years ago. Since that time he has been the owner and operator of the DeLuxe Cabin Camp at Wichita, and last year served as president of the association of camp owners for Kansas.

Mr. Church is survived by Mrs. Church, a daughter, two sons, his parents, and two brothers.

Arkansas CWA Farm House Plans

THE agricultural engineering department, University of Arkansas, in cooperation with the state CWA, has recently produced a set of twenty drawings of farm houses suitable for Arkansas conditions. The publication of these drawings is in loose leaf form and they may be obtained by writing to the Department of Agricultural Engineering, University of Arkansas, Fayetteville, Arkansas, for 20 cents per copy. If quantities of one or more plans are desired (in lots of 100 or more) they are obtainable at a cost of somewhat less than one cent each.

Personals

Robert B. Hickok has recently been appointed assistant agricultural engineer on the Zanesville, Ohio, project of the Soil Erosion Service, U. S. Department of the Interior.

D. W. Teare was recently appointed chief agricultural engineer of the Bethany, Missouri, project of the Soil Erosion Service, U. S. Department of the Interior. He was formerly in charge of agricultural engineering instruction at Clemson College in South Carolina.

Walter W. Weir recently received an appointment as cooperative agent of the Soil Erosion Service, U. S. Department of the Interior. Mr. Weir will serve the U.S.D.I. in a consulting capacity while continuing to carry on his work as associate drainage engineer, Division of Soil Technology, University of California.

New ASAE Members

F. M. Bozarth, concrete inspector, Grade "A", Kansas State Highway Commission, Topeka, Kansas.

Clarence F. Kelly, state foreman, Illinois Department of Conservation. (Mail) Camp 63-P, Herod, Illinois.

N. B. Morgan, manager of seed corn department, Morgan Brothers, RFD 1, Galva, Illinois.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the May issue of AGRICULTURAL ENGINEERING Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

L. F. Lawhon, technician, Emergency Conservation Work, Texas Erosion Control Camps. (Mail) Box 138, Cleburne, Tex.

James S. Maze, secretary, W. H. Maze Company, Peru, Illinois. (Mail) 2805 7th St., Peru, Ill.

Fowler McCormick, assistant domestic sales manager, International Harvester Co., Chicago, Ill.

G. E. F. Pickard, Guernsey, Sask., Canada.

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, senior agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture.

THE ATMOSPHERIC CORROSION OF DIFFERENT KINDS OF IRON AND MILD STEEL WIRE [trans. title], *J. Greger.* Statens Provningsanst., Stockholm, Meddel. vol. 58 (1933), pp. 1-12, figs. 3; eng. abs. pp. 16, 17. The results of an investigation of the atmospheric corrosion of different kinds of iron and mild steel wire during long-time exposure in the open air are reported as conducted by the Swedish Government Testing Institute. The test material included four kinds of mild open-hearth steel, three kinds of mild steel from electric furnace, four kinds of charcoal wrought iron, and one kind of armco ingot iron. One of the mild open-hearth steels and one mild steel from the electric furnace contained copper. All these materials were rolled to wire of 5 mm diameter, which was then cold drawn to 3 mm in the manner used for telegraph wire. The wire rings were boiled in a 5 per cent soda solution and then in water for cleansing and stabilization.

Physical tests made included tensile and torsion tests, and tests of electrical resistance. The corrosion tests included long-time field tests and short-period laboratory spray tests. In the field tests the materials were subjected to air contaminated with acid vapors and coal smoke and to sea air.

The corrosion was measured by determining the electric resistance of the wires in their original condition, and after exposure during certain periods. It was determined at the beginning, after 8 months, after 2 years, and after 4 years.

In the field tests corrosion was greatest in air contaminated with acid vapors and coal smoke, and least in sea air. The two copper-bearing steels showed the least corrosion. Of the remaining kinds of two open-hearth steels of ordinary quality with ordinary amounts of carbon and other constituents showed the least corrosion. The electric furnace steels and the remaining open-hearth steel showed the greatest corrosion. The charcoal wrought irons and the Armco iron showed very nearly the same corrosion and rank between the open-hearth steels of ordinary quality and the electric steels.

CORROSION TESTS ON MILD STEEL WIRE BY SPRAY METHOD [trans. title], *E. J. Virgin.* Statens Provningsanst., Stockholm, Meddel. vol. 58 (1933), pp. 12-15; eng. abs. pp. 17, 18. This is a report of the laboratory spray tests on the steels noted in the above report.

The spraying device consisted mainly of a circular disk of bakelite which was made to rotate slowly, 1 rpm, in a large porcelain container. Thirty test wires of 160 mm length were radially fixed on the disk. Two specimens of every one of the 15 kinds of wire were thus tested simultaneously. A 3 per cent NaCl solution was used. The spray was so arranged that only the mist reached the specimens. During the rotation of the disk the specimens were continuously revolved one-fifth revolution for each revolution of the disk. The specimens were sprayed twice daily, generally for 10 or 20 min from Monday to Friday and were allowed to dry on Saturday and Sunday. The test was continued during 46 days. The specimens were then cleaned by cathodic treatment in a 10 per cent KCN solution, examined and weighed. The loss of weight averaged about 5.5 per cent.

A comparison of the results of the long-time field tests and of the spray tests shows that the corrosion results in the more rapid laboratory salt spray test on different kinds of iron and mild steel wire do not correspond to the relative atmospheric corrosion of the same wires under actual working conditions.

FIELD AND LABORATORY VERIFICATION OF SOIL SUITABILITY, *R. R. Proctor.* Engin. News-Rec., vol. 111 (1933), no. 12, pp. 348-351, figs. 4. Consolidation and percolation tests of foundation soils are described, and results are presented from twenty-seven such tests on several types of soils when under loads equivalent to fills having depths of from 2 to 200 ft.

The data on percolation rates and the percentage of the soils finer than the 200-mesh screen showed that no definite relation exists between them. It is shown, however, that the extent to which the soil is compacted is much more important for obtaining watertightness than the percentage of fines.

None of the soils tested showed an excessive percolation rate, and most of the rates shown are so low that the soil may well be classed as impervious to water. The percolation rates through all soils tested are negligible when they are compacted to the condition of a minimum plasticity needle penetration resistance of 300 lb per square inch when saturated. Any soil that meets this condition could probably be used in a dam. It is unlikely that the percolation velocity would be sufficiently high to erode any of the fines from the soil.

SOIL EROSION CONTROL BY TERRACES, *C. E. Ramser.* Engin. News-Rec., vol. 111 (1933), no. 15, pp. 437, 438, figs. 3. In a brief contribution from the U.S.D.A. Bureau of Agricultural Engineering, the results of research at the several soil erosion experimental farms on the influence of terrace slope, spacing, and length upon the waste of soil and water are summarized.

Outstanding among the results obtained on the design of terraces is the information collected on the farm at Tyler, Tex., which supports the recommendations made in 1916 that a terrace with a variable grade is more effective in controlling erosion than a terrace with uniform grade. Measurements of the discharge from two terraces 700 ft long, one with a uniform fall of 6 in per 100 ft, and the other with grade varying from 0 to 6 in per 100 ft, showed that two-thirds more water and one-third more soil were removed from the former during the year 1931. At Bethany, Mo., the relative efficiency of variable and uniform grades was indicated by an experiment consisting of two terraces about 1,200 ft long, one with a uniform fall of 4 in per 100 ft and the other with a fall varying from 0 to 4 in per 100 ft. Nearly twice as much soil was lost from the uniform graded as from the variable graded terrace.

FEED HOPPERS AND TROUGHS. Mass. State Col. Ext. Leaflet 76, rev. (1923), folder, figs. 2. Drawings and a bill of materials are presented.

DIAGRAM REPRESENTING THE REAL PHENOMENA OF COMPRESSION, COMBUSTION, AND EXPANSION IN HIGH SPEED MOTORS [trans. title], *A Grebel.* Compt. Rend. Acad. Sci. (Paris), vol. 195 (1932), no. 25, pp. 1230-1232, fig. 1. Diagrams are given using the coordinates pressure and time. These are considered to be more suitable than the pressure volume coordinates for representing the effects due to the delayed starting of the initial ignition which decides the ultimate performance, the presence or absence of knock, and the thermodynamic efficiency of the engine.

INSULATION FOR HOUSE CONSTRUCTION, *J. D. Hoffman.* Purdue Univ., Engin. Ext. Ser. No. 31 (1933), pp. 31, figs. 19. Technical information is given on the computation and installation of house insulation.

ARTIFICIAL LIGHT AND ITS APPLICATION IN THE HOME. McGraw-Hill Book Co. (New York and London), 1932, pp. VIII+145 [pls. 2], figs. 43. This book, which was prepared by the Committee on Residence Lighting of the Illuminating Engineering Society, has for its purpose the presentation of a practical, concise, and reliable treatment of artificial lighting and its application in the home. It contains chapters on light and people, fundamentals of lighting, characteristics of incandescent lamps, light and color, fundamentals of electricity, wiring for the home, lighting equipment, and lighting the rooms of the home. A dictionary of illuminating terms is included.

LUBRICATING OILS WITH COLLOIDAL ADMIXTURES [trans. title], *O. Steinitz.* Allg. Oel u. Fett Ztg., vol. 29 (1932), no 1, pp. 35-37. The author summarizes experiments by himself and others to show that the addition of colloidal graphite to lubricating oils improved the properties of the oils to decrease friction and heating in journal bearings. Oil utilization also was decreased. When used in an internal-combustion engine, the graphited oil improved acceleration and decreased friction, heating, and oil utilization.

GRAPHITED LUBRICANTS. U. S. Dept. Com., Bur. Standards Letter Circ. 387 (1933), pp. 3. Practical information is given on the value of lubricants containing graphite in internal-combustion engines. It is pointed out that the action of graphite in oil usually is to lower the viscosity, thus lowering the friction. It appears, therefore, that the lowering the friction is not due to the graphite itself but to the lowered viscosity. The same effect could be secured by using lower viscosity oil. *(Continued on page 210)*

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Apparently the main advantage of using graphited lubricants is in engines with worn and scored friction parts.

COSTS OF CLEARING LAND ON MINNESOTA FARMS, *M. J. Thompson, L. H. Schoenleber,* and *N. A. Kessler.* Minnesota Sta. Bul. 299 (1933), pp. 28, figs. 8. This bulletin reports the results of an analysis of the costs of reclaiming stump and stone lands in northeastern Minnesota, conducted in cooperation with the U.S.D.A. Bureau of Agricultural Engineering. The data relate to 122 farms in 11 counties and cover the clearing of 371 acres of stumps and stones. The data also relate to sand, sandy loam, clay loam, and clay soils. A distinctive forest cover was associated with each soil type.

Brushing was done on 194 acres and 66 farms. The time required per acre varied from 1 day on clay to nearly 5 days on sandy loam. The average was 3 days. This covers burning as well.

Stumping was done on 320 acres and 104 farms. Man labor ranged from less than 3 days on sandy soil to 5¾ days on clay, with the mean 4 days (42 hours). Horse labor required was 2¾ days per acre. Stumping covers four subdivisions of labor: Blasting, pulling, piling, and burning. The 42 hours stumping time may be apportioned thus: Blasting 10 h, or one-fourth the time; pulling 1½ days or one-third the time; piling 13 hours, or less than one-third the time; and burning 5 hours, or nearly one-eighth the time.

Sandy soil took the least explosive, and clay took the most. The average acre required 127 sticks of explosive, 84 feet of fuse, and 60 caps. The diameter of blasted stumps was as follows: On sandy soil, 9.2 in; on sandy loam, 11.1 in; on clay loam, 13.2 in, and on clay, 14.6 in.

Breaking, including disking and seedbed preparation, was done on 221 acres and 76 farms. Horse labor was used in all cases. Breaking was done most rapidly on sandy soil and most slowly on stony clay loam. The average acre took exactly two days to break, for man and team. Eighty acres of land were stoned. This required more than one 10-h day for the average acre. Clay was even freer of stones than jack pine sand. Roots were picked off 166 acres. The job took just a fraction over ½ day of man labor per acre. The picking was lightest on clay soils which grew the largest stumps. Stump hole filling and associated trimming jobs took over a day per acre.

The 12 days of man labor were distributed thus: Brushing 3 days, stumping 4 days, breaking-disking 2 days, picking stones and roots nearly 2 days, and miscellaneous 1½ days. To clear an acre of sandy land required 7¾ days, of clay 9¾ days, of sandy loam 12 days, and of clay loam 15 days. The amount of material used per acre varied in the following order: Sand least, sandy loam, clay loam, and clay. Breaking was the big job for horses. Other jobs in declining order were: Stumping, stoning and picking roots, and miscellaneous. Light soils were cleared at a lower cost than heavy soils.

THIN FILM LUBRICATION OF JOURNAL BEARINGS, *M. D. Hersey.* Jour. Wash. Acad. Sci., vol. 23 (1933), no. 6, pp. 297-305. A mathematical analysis of thin film lubrication is presented, with particular reference to factors affecting the determination of the coefficient of friction. The application of a dimensional theory is demonstrated.

COMPARISON OF METHANOL AND OTHER ANTI-FREEZE AGENTS, *T. C. Albin.* Chem. and Metall. Engin., vol. 40 (1933), no. 10, pp. 526, 527, figs. 2. Data are reported graphically showing the important relationship of methanol to ethyl alcohol with reference to anti-freezing properties, and to acetone, the common impurity in wood methanol. It is shown that for all concentrations up to that giving about —25 deg F as a freezing point, the vapor concentration of methanol is less than that of ethyl alcohol for a given amount of protection. However, with concentrations below that affording —5 deg freezing point, the actual boiling point of the methyl alcohol is higher. At greater concentrations the ethyl alcohol has the higher boiling point.

Specifications for methanol antifreeze stock before adding diluting water or color safeguards are proposed.

THERMAL INSULATION, *E. Griffiths.* Inst. Chem. Engin. [London], Trans., vol. 10 (1932), pp. 35-41, figs. 7. Studies of the thermal conductivity of some of the materials used for insulating purposes are reported, and descriptions of the apparatus used for testing wall sections and materials of coarse structure, materials used in refrigeration, and refractory materials are included.

The results for the different materials are presented in tabular form.

THE SILT LOAD OF TEXAS STREAMS, *O. A. Faris.* U. S. Dept. Agr., Tech. Bul. 382 (1933), pp. 71, pls. 2, figs. 12. This is the first progress report of investigations on the silt load of Texas streams which were conducted in cooperation with the Texas Board of Water Engineers. The Brazos River Basin was selected as a drainage area typical in its various sections of conditions prevailing on other drainage areas. Sampling stations were established at gaging stations, either near favorable reservoir sites or below areas comparable to other drainage basins.

It was found that the mean percentage of silt by weight in samples taken at 6/10 of the depths in verticals at 1/6, ½, and 5/6 the width very closely approximates the mean silt percentage for the section.

While it is known that steep mountain streams transport considerable coarse material by rolling it along the stream bed, it is believed that the solids conveyed by the streams studied at the sections under consideration are held in suspension and subject to sampling at velocities existing during periods when silt is being transported in significant quantities.

There is no evidence at the river stations under consideration of any direct relation between the suspended load and the velocity of the water. The higher the velocity the greater is the capacity to carry, but since the capacity load is not even approximately approached, the magnitude of the silt charge becomes in effect a function of loading rather than of capacity to carry. The greater part of the silt load of a stream is due to previous weathering.

The maximum silt percentage by weight occurs prior to the maximum stream discharge. There are two distinct peaks in the silt percentage curves for each flood. The first peak occurs on a rising stage at a point above which the volume of water increases much faster than the available silt load, resulting in dilution. The second peak occurs on a falling stage and is due to the caving of banks and the sloughing into the channel of material deposited on the slopes at higher stream stages.

The greater part of the suspended silt load of streams and of most of the material deposited in reservoirs is of such fineness that it will pass a Tyler Standard No. 300 sieve.

After 7 days' settlement, the average ratio of the percentage of silt by volume to the percentage by weight is 3.3:1. The mud column of samples kept in tubes for 7 days is comparable to freshly deposited material in reservoirs, but being taken from suspension, it contains a mixture of different sized grains, while material deposited in reservoirs has been subjected to more complete sorting.

Suspended silt settles to the reservoir bottom soon after entering the slack water and, having a greater specific gravity than water, flows in the form of liquid mud down the slopes into depressions and along the main channel until blocked by the dam.

Owing to its greater density, silt-charged water entering a reservoir partly filled with clear water does not mingle with the clear, but forces it downstream toward the dam. No suspended silt is carried through the reservoir and over the spillway until all of the clear water has been discharged.

Silt deposited from suspension in reservoirs and kept continually submerged contains from 18.7 to 37 lb of dry material per cubic foot of deposit. The average weight of the dry material per cubic foot of deposit in reservoirs in which a practically constant head is maintained approaches 30 lb. The average weight of the dry material per cubic foot of deposit in reservoirs that are emptied occasionally, ultimately approaches 70 lb. The average weight of dry material per cubic foot of deposit in reservoirs used exclusively for flood control and therefore standing empty most of the time approaches 90 lb. The greater part of the silt deposited from suspension in reservoirs and kept continually submerged has an angle of repose approaching 0 deg.

The specific gravity of dried silt from reservoir deposits is generally about 2.65. Samples taken from suspension and from which vegetable matter was excluded had an average specific gravity of 2.73.

Excess water held in silt by virtue of the structure of the deposit is not available as storage water. On exposure of such deposits to the air, the water is liberated so slowly that all of it is evaporated. Although the moisture content of exposed silt deposits increases when resubmergence occurs, silt that is not actually scoured and agitated by incoming floods until complete separation of the particles takes place does not occupy as much space as when it was deposited. Each subsequent exposure and submersion results in a greater degree of consolidation.

The density of silt deposited in reservoirs is not increased by the depth of water on its surface. Actual tests of material submerged from only a few to over 100 ft indicate no difference in density. Since the individual silt particles are completely surrounded with water the resultant pressure is zero.

Seventy pounds was selected as the average ultimate weight of

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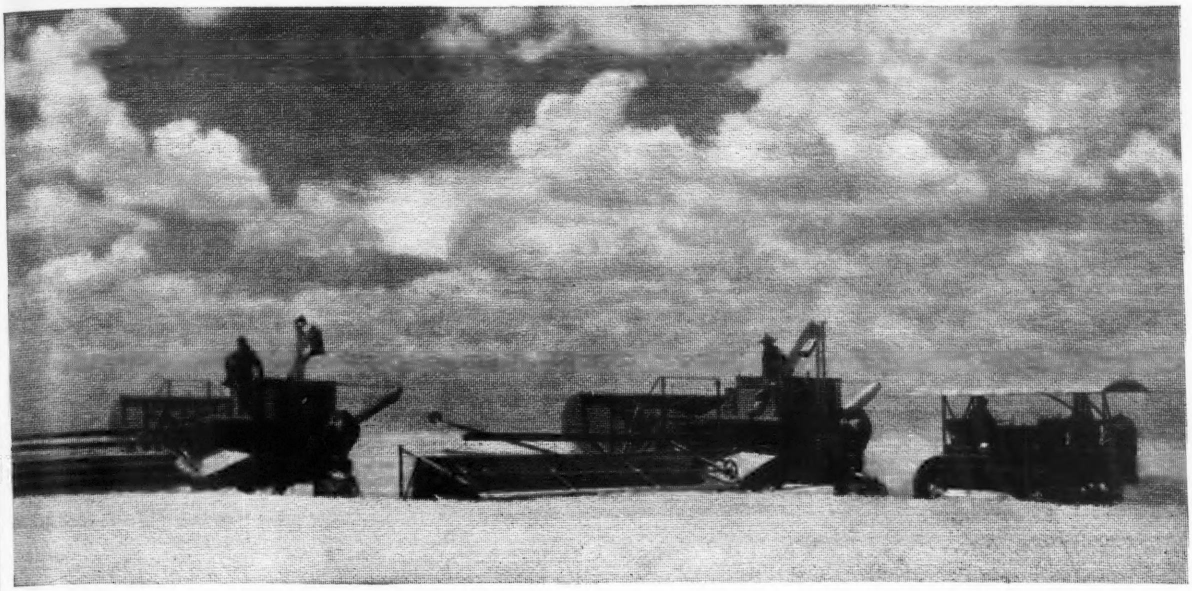

"Labor-Saving: A Misnomer"

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All of the foregoing has been considered in terms of occupation and employment, which in the present state of affairs seem to be uppermost in social expediency and economic policy. In terms of production per worker—or its reciprocal, hours of labor per unit of product—the increase in efficiency is too obvious and too well known to require restatement here. Multiplying the moderately reduced employment (in the zone of social benefits herein considered) by the greatly enhanced output per worker leads mathematically to the conclusion that the sum total of products and services available to the population at large is far greater than in the pre-machine age; this, too, is confirmed by common observation.

Assuming a reasonably equitable distribution of the fruits of labor, this all means that the end-product of the machine takes the form of abundance in material blessings, or raised standards of living. So prolific is the machine in bringing forth these blessings that per-capita production capacity has increased in spite of, or in addition to, reduction in hours of labor to about half what they were when 90 per cent of the people lived on farms, with further reduction apparently in order.

In this sense of reducing the hours of work, and to a still greater degree in driving out drudgery and making labor less laborious, the machine has perhaps its strongest claim to the term "labor-saving." In so doing it has added not only to the comfort, but to the dignity of labor. Directly and indirectly it has been a major factor in admitting women to many gainful occupations. This, while accompanied by certain dubious social implications, undoubtedly constitutes a large degree of economic emancipation.

In our own field we have seen the unpaid labor of women in corn harvest disappear with the appearance of the machine corn-picker, and the presence of the milkmaid in the dairy barn, in which none but a poet could see any poetry, give place to the milking machine. Even if the lady corn-picker is offset by a sister-under-the-skin working in the milking machine factory, or the milkmaid becomes secretary to the manager thereof, there is net gain in the dignity and reward of labor, and less of drudgery in its performance—again maintaining employment while saving labor.

So, too, with child labor in agriculture. Not in great-great-grandfather's time, but in the memory of some of us, the rural school year was adjusted to the rush season of crop production so that boys could help with cultivating, haying, grain shocking, potato picking, and sometimes corn-picking. Appraising the type of manhood which developed with such apprenticeship, I do not concede child labor on the farm to be the dire evil which some reformers have painted it. Be that as it may, farm work no longer controls school schedules in regions where crop production is well mechanized. The problem now is to get the farm boy acquainted with farming. Only in those exceptional and numerically unimportant cases where children do hand weeding, thinning, berry-picking, etc., does child labor in farming remain open to rational criticism. It is the machine which keeps the rural school open eight or nine months a year, and sends the farm youth to high school.

All of these things mean richness of living and widening of opportunity, not restriction of opportunity or reward for labor. However accurate "labor-saving" may be as applied to the machine in a narrow sense, it neither denotes nor suggests the end-product of the machine in terms of human well-being. It is a phrase with the curse of negation upon it, like wireless, horseless carriage, and B-eliminator. If we can find instead some simple, vivid phrase which emphasizes the affirmative blessings of the machine, it deserves serious consideration. —W. B. JONES

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the dry material per cubic foot of deposit in reservoirs where the deposits are subjected to alternate wetting and drying.

The best method of preventing the deposition of silt in reservoirs is to keep it from being carried into the supply streams.

A list of 24 references to the works of others bearing on the subject is cited, and an appendix is included giving data on silt carried by various Texas streams based on discharge records of the U. S. Geological Survey.

Literature Received

1934 BUYERS' GUIDE. Volume 43 of a classified directory of manufacturers of farm and garden implements, tractors, wagons and carriages, motor trucks, lighting plants, cream separators, gasoline engines, windmills, pumps, wire fencing, and many other accessory lines sold by farm equipment dealers, and issued annually by the Farm Implement News Company, 431 South Dearborn St., Chicago, Illinois, has just been published. This publication contains an exhaustive index of farm equipment classifications, a classification according to implements, tractors, vehicles, repairs, etc., and the names and addresses of the corresponding manufacturers, including the trade names of the equipment. It also contains a general directory of manufacturers of the United States including their full lines, branch houses, jobbers, etc., and finally an alphabetical list of manufacturers, including their addresses.

EMPLOYMENT BULLETIN

An employment service is conducted by the American Society of Agricultural Engineers for the special benefit of its members. Only society members in good standing are privileged to insert notices in the "Men Available" section of this bulletin, and to apply for positions advertised in the "Positions Open" section. Non-members as well as members, seeking men to fill positions, for which members of the Society would be logical candidates, are privileged to insert notices in the "Positions Open" section and to be referred to persons listed in the "Men Available" section. Notices in both the "Men Available" and "Positions Open" sections will be inserted for one month only and will thereafter be discontinued, unless additional insertions are requested.

Men Available

ELECTRICAL ENGINEER, graduate of the University of London, desires employment as rural service engineer or distribution engineer with an electric power company, or as research engineer in rural electrification with an agricultural experiment station, preferably in eastern or western United States. Seven years experience in rural electrification with electric power companies and in research at a state agricultural college. Age 33. MA246.

AGRICULTURAL ENGINEER, graduate of Michigan State College, at present working for master's degree at University of Minnesota (with major in farm power and machinery), desires employment with farm equipment manufacturer either in engineering or sales work. Born and reared on a farm. In connection with college work, he has served as teaching and research assistant, all the work being in farm machinery. Available April 1, 1934. MA247

AGRICULTURAL ENGINEER, graduate of Virginia Polytechnic Institute and licensed surveyor, with varied experience in surveying and construction work, and three years' carpentry experience, desires employment as surveyor or with construction company. Single. Age 27. Will go anywhere. MA248

AGRICULTURAL ENGINEER with both bachelor and master of science degrees (majoring in agricultural engineering) from midwest universities, two summers' experience as irrigation investigation engineer in midwest state, experience in soil erosion work, and five years' experience with agricultural engineering department of large university where the duties consisted of research work in reclamation, farm development, land use study, and a regular teaching schedule mainly in reclamation, desires employment where qualifications meet the need, preferably with farm equipment company, in federal work, or in agricultural engineering with some state agricultural college. Married. Age 27. MA249

AGRICULTURAL ENGINEER, graduating this June as a member of the first agricultural engineering class from University of Illinois, with twelve years' experience as draftsman, tool and jig designer, designer of automatic machinery, and foreman of mechanical research and development department. Prefers to locate in the Southwest. Available July 1. Age 40, married. MA-251

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